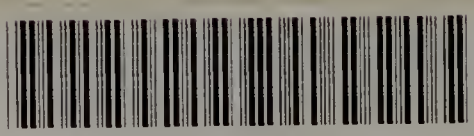
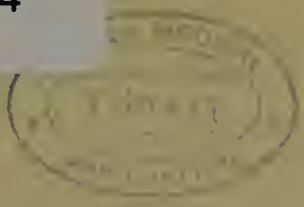
VISUAL ECONOMICS

MAGNUS and WURDEMANN





VISUAL ECONOMICS,

WITH RULES FOR

ESTIMATION OF THE EARNING ABILITY AFTER INJURIES TO THE EYES.

BY

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FOR THE USE OF THE MEDICAL AND LEGAL PROFESSIONS, BUSINESS CORPORATIONS AND INSURANCE OFFICIALS.....

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DEDICATED

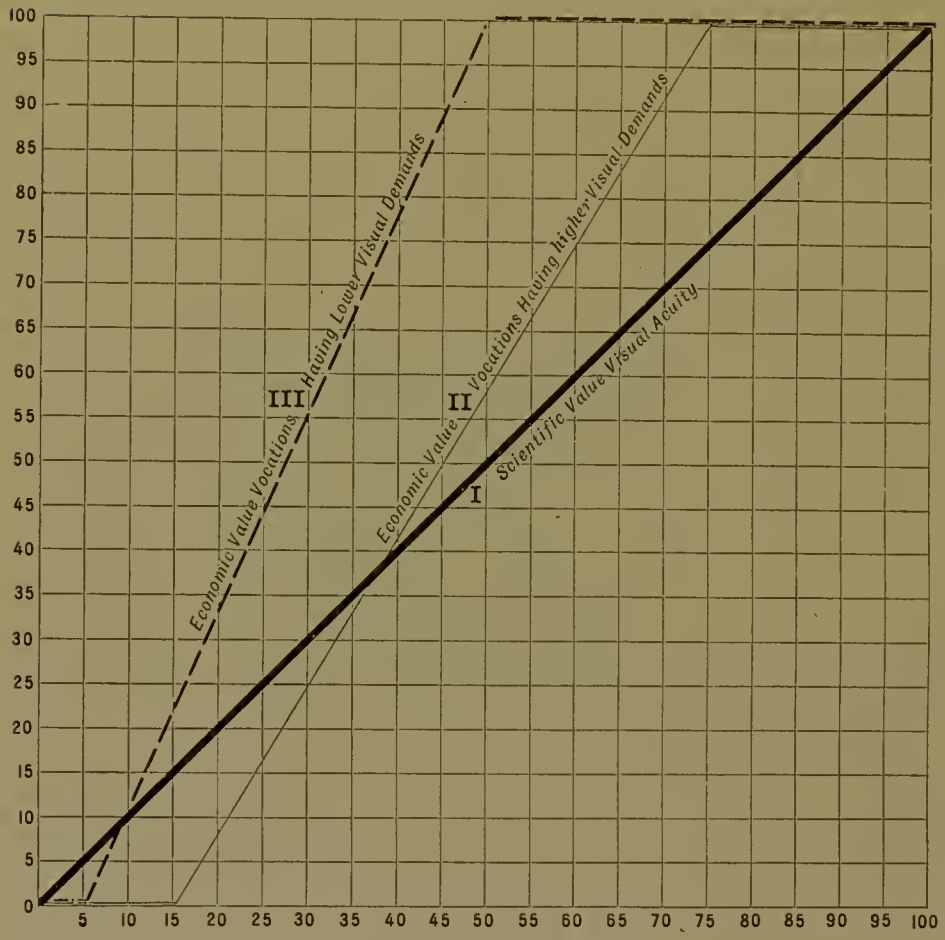
to the

HON. JOSEPH V. QUARLES,

Senator of the United States of America
and Member of the Wisconsin Bar.

PLATE I.

FOR TRANSPOSITION OF THE SCIENTIFIC STANDARD OF VISUAL ACUITY INTO ECONOMIC TERMS.



The coarse full line (**I**) denotes the course or curve of the Visual Acuity according to the Scientific Standard.

The fine full line (**II**) is the Economic valuation for vocations having higher visual demands, and the broken line (**III**) the Economic valuation for lower demands.

(See text Chapter VI., § 12, and Chapter VIII., § 17.)

PREFACE.

THE great interest and large circulation with which the original edition of Magnus' work, "Leitfaden für Begutachtung und Berechnung von Unfallsbeschädigungen der Augen," was received after its publication in 1894, the legal standing which this and the second edition of 1897 has achieved in Germany, the fascination which the reading of the original work had for the American author, and the practical use which he has made of the formulas and maxims of Magnus, led him, in May, 1900, to request the permission of Prof. Magnus to allow of a translation, adapted to the legal, medical and economic requirements of America, to be published in this country, which was cheerfully given May 11th. The American editor at first made a literal translation of the work, but owing to the virgin field, as yet untouched in English medical literature, and almost unthought of in insurance circles, and the special demands of American law, it was believed that a simple translation would not meet the requirements of American and English readers. Therefore, with the consent and aid of Prof. Magnus, the work has been entirely re-written by the American author. The introduction and all of Chapters I, XIX and Part III are new. A large part of Chapter VI, i. e., that more particularly relating to American railway employees, and interpolations in many places throughout the text are new. The formulas and calculations are adapted from those in Magnus' second edition. We are greatly indebted to Dr. Howard F. Hansell, of Philadelphia, for hints and extracts from his paper, "Estimation of the Amount of Injury to the Earning Capacity of the Individual from Partial or Complete Loss of Vision"; likewise to Dr. Frank Allport, of Chicago, for information relating to classes of railway employees, and to Senator Joseph V. Quarles, of Wisconsin, for assistance upon the forensic portion of the work.

The reason for the publication of Magnus' original essays was the passing of a Benefit and Accident Insurance Law in 1884, in Germany, which placed upon the already overburdened shoulders of the physician entirely new and difficult problems. The estimation of the damage from eye injuries and indemnity to be allowed therefrom had heretofore only been made from a philanthropic standpoint. Zehender was the first to try to give a mathematical expression to such estimations, fol-

lowed later by Magnus, Groenouw and others. Magnus' calculations are the only ones that are founded upon anatomical and mathematical data. He called to his aid an expert mathematician, Dr. Hugo Rohr, who gave valuable assistance in the compilation of the tables. Magnus' methods, which have been adapted to the use of American and English-speaking peoples in this edition, may be carried out in actual practice, so that a method for estimation of the damage to any workingman's capacity from ocular injuries and the indemnification to be given therefor, may be figured in a manner just to the workman, the person responsible for the damage, to his employer or to the casualty company. We hope that this work will not only prove acceptable to the medical profession of America and Great Britain, but also be received with interest by that of the law, by insurance companies and by corporations which are responsible for pecuniary indemnification in the case of accidents to the eyes.

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Milwaukee.

Jan. 1, 1902.

CONTENTS.

PART FIRST.

PART SECOND.

Special Consideration of Various Ocular Injuries.

PART THIRD.

PART FOURTH.

PART FIRST.

Introduction. Legal Status of the Physician in Relation to Accident Insurance and Indemnity for Accidents. Different Methods for Estimation of the Loss of Earning Ability from Ocular Accidents. General Principles for Estimation of the Relation of Ocular Injuries to the Earning Ability. Conception of the Earning Ability and of Injuries thereto. Estimation of the Damage to Economic Vision. Method of Mathematical Calculation.

INTRODUCTION.

As the subject of which we treat in the following pages enters into the domain of legal medicine and from its technical side no one in America or among English-speaking peoples has yet had the temerity to exhaustively treat it, and with the exception of a brief essay which the American editor as chairman (2) had arranged for the Section on Ophthalmology of the American Medical Association and which was ably given by Hansell (17), some medico-legal excerpts and scraps here and there in medical journals, the literature is almost entirely German; we will, therefore, be obliged to deal mostly with the facts and theories that have been brought forth by German writers, more especially those of Magnus, the status of this subject in America in the law courts with the Accident Insurance Companies and the United States Pension office, and then take up the German Accident law, after which we will proceed to the scientific estimation of the visual earning ability.

In this work we start with the supposition that the earning ability for any gainful vocation requiring eye sight is practically synonymous with the visual earning ability, and that injuries to the eyes affecting the vision have a direct detrimental effect upon the earning capacity of the individual (See Chap. IV., § 9, p. 26; Chap. VI., § 11, p. 30; Chap. VI., § 12, p. 36). It is self-evident that a totally blind person is absolutely incompetent to work at any trade or in any profession which demands eye-sight, and that the vast majority of blind people are not only incapable of earning anything, but are a charge upon their families and upon the community. But even the blind man, provided that he has had the necessary education and experience, need not remain absolutely idle or be perfectly dependent; for in some vocations where the use of the mental powers is the chief factor, such as banking, some mercantile pursuits and professions where knowledge may be assimilated through the eyes of others or by methods peculiar to the blind and by the actual work being done by employees, some specially well placed and talented individuals may continue to be economic factors. But these are exceptions, and there can be no doubt that the possession of good eye-sight is the prime factor for full earning ability for the greater majority of gainful human

vocations, and any injury to it is usually followed by a lessening of the earning ability and of the resultant compensation. We consider that with laborers or artisans, in fact any of the so-called working classes, who may by accident acquire some defect of eye-sight, ranging from partial to complete blindness in one or both eyes, that the effect of this visual defect upon the earning ability will be identical with the percentage of the loss of eye-sight or visual earning ability.

A decision of this character has not yet been reached in American courts of law, but we have no doubt that it must soon be made, and when such a precedent is established, the damage to economic vision will, in every case, be estimated in a scientific manner and be given a prominent position in judging the amount of damages to be allowed in personal damage suits, of which a considerable number relate to the eyes. We likewise hope that the factor of visual economic damage will be sometime taken into consideration in insurance circles and by the United States government in establishing the rates of insurance and pension annuities. We are convinced that this factor has been estimated in the following pages in a scientific manner and we confidently assert that in any given case where the eyes have been injured we can figure the amount of damage to the earning ability. It is fortunate that the state of ophthalmic science allows of a definite estimation of the working powers of the eye. This is not so in respect to other corporal functions, for instance, the economic loss of an arm or a leg or the loss of the sense of smell or of hearing certainly cannot be as exactly estimated as that of the sense of sight. Upon the latter depends our earning power and the others but partially and temporarily affect it. Gainful occupations may only be followed when the sense of sight and the mental faculties are unimpaired. The loss of the visual powers invariably has a delcterious effect upon the calling dependent upon the degree of damage and the nature of the vocation which may be shown in dollars and cents.

The work that we present may perhaps establish a standard for the use of courts of law and accident insurance companies, which now have no uniform methods of estimating the value of an individual's sight.

CHAPTER I.

THE LEGAL STATUS OF THE PHYSICIAN IN RELATION TO ACCIDENT INSURANCE AND INDEMNITY FOR ACCIDENTS.

§1. *The Legal Status of the Physician in the United States of America and Definition of Damages.*

Most indemnity claims in America are adjusted according to the opinion of a reputable physician, more especially on the advice of the official medical adviser or examiner of the insurance, traffic or manufacturing company, or of the U. S. Pension office physician, or upon the sworn statements of those deputized for examination of the special case, with the exception of contested cases and suits for damages, etc., which are settled in the courts of law. In most of the States of the Union, the physician or oculist may be compelled to testify as a common witness or may be brought into the case as an expert; in either event he may be required to give expert testimony.

The principles of expert evidence and medico-legal expert testimony are outlined by Sinkler (Baudry 4) as follows:

(a) As to Expert Evidence in General.—A principle of the law of evidence is stated by an authority on the subject as follows: "The fact that any person is of opinion that a fact in issue does or does not exist is deemed to be irrelevant" (Stephen 42). But the same writer notes an exception to this rule. "Matters of opinion are admissible." "Where there is a question as to any point of science or art, the opinions upon that point, of persons specially skilled in any such matter, are admissible." The words science or art are taken to include all subjects on which a course of special study or experience is necessary to the formation of an opinion. "But opinions of experts are admissible only in relation to their art, and not as to matters of common knowledge."

Medico-legal Experts.—The opinions of medical men are constantly admitted as to the cause of disease or death or the consequences of wounds, or the treatment of sickness; and as to the sane or insane state of a person's mind as collected from a number of circumstances, and as to other subjects of professional skill (Taylor 43.) But his special knowledge must be established and his examination confined thereto (Greenleaf 9.) "A physician may testify as to cause of death (or disease), from personal examination or knowledge, but his testimony extends no further than the immediate cause, because, manifestly, that is the limit of science." (Wis. Repts., Vol. 101, p. 278.) (50)

As to What Should Form the Basis of the Expert's Testimony in a particular case; the opinion, to be admissible, must be founded either on his own personal knowledge of the facts testified to in court or upon an hypothetical question (Bell 6.) His evidence as to facts must be the result of his own examination. A physician may not give his opinion as to a case in which he was called into consultation and where his knowledge of the case is derived solely from the discussions with his fellow-consultant. A physician's opinion is not admissible if based on statements made to him by parties out of court and not under oath (Lewis 23.)

(b) Legal Measure of Damages.—Damages is defined by Taylor (44) as "the injury or loss for which compensation is sought," and the measure of damages refers to the amount or extent of such injury or loss. Three distinct kinds are recognized and awarded to suit the merits of the case:

First. Nominal Damages, or some trifling sum which is awarded when a breach of duty or infraction of the plaintiff's right is shown, but no serious loss is proven to have been sustained. Such are awarded for violation of a plaintiff's right, but where no damages are shown by the evidence.

Second. Substantial or Compensatory Damages.—These are such as are designed and awarded to compensate for the actual loss or injury sustained. The jury weighs the evidence and fixes the amount which in their opinion properly compensates the injured party for the loss suffered.

In this work only the after-effects of the accident, the economic damage, is figured. In addition to this, American courts allow the amount actually expended in the necessary treatment following the accident, the monetary valuation of the time lost, the amount of injury to the business of the individual, and indemnity is claimed and allowed for the mental effect, the pain and anguish suffered by reason of the accident. The amounts of all these factors are arbitrarily allowed together by the courts. *The only factor that can be fixed with scientific exactness is the actual loss to the earning ability which follows the accident, the estimation of which is the business of this book and which should be the principal basis for settlement of all claims.*

Third. Exemplary or Punitive Damages, also termed vindictive. This class exceeds the loss actually sustained, and is given as a kind of punishment to the defendant.

§2. *Accident Insurance in America and Estimation of Indemnity for Accidents to the Eyes.*

(a) The Estimates Made by the American Accident Insurance Companies are now based upon empiric ideas and the results of experience, such as the proportion of eye injuries to those

of the other parts of the body, upon the ratio of losses to the whole number of insured, and upon the amount of premium the insured is willing to pay in ordinary risks. In other words, the general principle of insurance is the foundation for the incurring and settlement of eye cases (Hansell 17.) For example: "When the loss or partial loss of vision totally disables the insured from performing all his duties, total disability is paid. When it disables him from performing one or more of his duties, partial disability is paid. This ruling naturally holds in cases of disability from other than ocular causes" (Preferred Mutual.) The Travelers' Insurance Co. said: "There is no general method of estimating the pecuniary disability in cases of partial loss of vision for several reasons. One will suffice. No accident policy ever written has undertaken to estimate such disability. On the contrary, the insurance contract is either a valued policy, fixing a definite sum in the event of loss of vision in one or both eyes, or it names a definite sum to be paid as weekly indemnity for total or partial loss of time resulting from eye injuries." The Aetna Co. replied: "The method of estimating pecuniary indemnity in cases of partial or complete loss of vision from accident, depends upon the form of policy which the insured has purchased. If his occupation is such as to entitle him to insurance in the select or preferred class, the indemnity payable for total loss of sight of both eyes would be equal to the full amount of his insurance, being therefore placed upon the same basis as a fatal accident. The loss of the entire sight of one eye is compensated for by the payment of one-eighth the amount that would be paid for the loss of both eyes. If the loss of sight is partial (temporary) and its temporary loss results in the insured being unable to perform the duties of his occupation, he is indemnified for such loss of time simply, just as though he were injured in any other organ. As to loss of vision from disease: under our special health policy provision is made that in such an event an amount equal to 100 weeks' indemnity for total disability will be payable. Payments made by insurance companies for such loss were originally arbitrarily fixed and the experience of the companies has not been of such nature as to make it necessary to modify the same materially."

Thus by agreement between the insurance companies and the insured, the former assume the risk of being called upon to pay sums ranging from $600 to $1,000 for one, and $5,000 for the loss of both eyes, provided the insured pays a certain yearly sum. The amount is determined by the ratio of eye injuries to injuries of other parts of the body and to fatal injuries, taken from a large number, and the willingness of the insured to pay a yearly premium commensurate with his own conception of the pecuniary value of an eye and of vision and of the risk he believes he incurs. This is a purely mutual and financial arrangement and is made independently of age, sex, occupation (excluding special risks) and annual income.

(b) THE UNITED STATES BUREAU OF PENSIONS has fixed the rates of pension for disability arising from disease of the eyes thus: "Total blindness of both eyes $72.00 per month; loss of one eye $17.00 per month; loss of sight of one eye $12.00 per month. In cases of disease of eyes causing defective vision, the rates vary from $6.00 to $50.00 according to rank and pay." (17)

§3. *The German Accident Insurance Law.*

July 6, 1884, there was an accident insurance law passed (von Woedtke 46) which is now in force in the German Empire. § 5 defines its intention as follows: Compensation for the loss resulting from bodily injury or death is to be adjusted according to the following provisions:

1. The cost of necessary treatment commencing at the beginning of the 14th* week after the accident.

2. A regular income to be paid to the injured person from the beginning of the 14th week during the time of his inability to work.

The wording of the law shows that neither the injury itself nor any temporary results, such as the detention from work or the expense of treatment up to the 14th week thereafter, is considered grounds for indemnification, but it relates solely to the effects when they have had a more permanent detrimental influence upon the earning powers.

Section II, § 5 shows that the law-makers had no other intention and the law should not be interpreted in any other sense. The law does not mean that under all circumstances injured persons should receive indemnification.

We agree with Mooren (29, p. 29) when he says, "The presence of an ocular imperfection does not constitute a claim for indemnification, but only the existence of inability to follow a trade or profession resulting from such imperfection can be so considered." If the physician desires to do his duty, he cannot depart from this interpretation of the law. While there is no doubt that the effect of this Accident Insurance Law is not to indemnify the insured for the injury itself, but only for the impairing of the earning ability, it has not yet been definitely decided who shall be the authority for determining the extent of this loss of earning ability and especially the amount of the indemnification. Some claim that this is the duty of the physician, others that it is the exclusive right of the courts and the insurance officials.

*It will be noted that this Insurance Law deals only with the results of accidental injuries after 14 weeks have elapsed from the date of the accident. The reason for this may lie in the fact that most German manufacturers pay their City Hospitals certain sums, (which have been retained from the workman's wages) for the care of their sick employees and indemnification for accidents is considered due only after the lapse of 14 weeks.

What is an eye worth in America? To any of us sight is priceless, but the courts award from $1,000.00 to $8,000.00, the latter being the highest indemnity yet given. See Dela Vergne Refrigerator Co. vs. Stahl, Court Civil Appeals, Texas, 1901, Journal A. M. A., 1901.

§4. *The Determination of the Corporal and Economic Damage from Injuries Belongs to the Physician, the Estimation of the Monetary Compensation to the Corporations and the Courts.*

Foerster (7, p. 16) considers that the duty of the physician is only to attest to the kind of injury, leaving the estimation of its effect upon the earning ability to the trade association. To this we cannot agree; for instance; what help will it be to the insurance officials or to the average juryman if we inform them that a certain injured person has suffered from "a paralysis of the musculus externus sinistra?" In order to properly judge of the relations between the laming of an ocular muscle and the earning capacity, technical physiologic knowledge is certainly needed, and verily, we cannot expect a tradesman to have a scientific mind. A physician can much sooner acquire a knowledge of the technical peculiarities of the different trades than the trade association can get even a modicum of medical knowledge. There are but few vocations with which a physician does not come in contact. Wagner (38, p. 21) states that it is the duty of the physician to acquire some knowledge of the trades of the patients with whom he deals, as by this means he is enabled to estimate the relation of the injury to the loss of the earning ability. To the foregoing we heartily agree. It is the province of the physician to estimate the proportional loss to the earning ability resulting from disease or traumatism, for who among men is, from his training and daily work, so well qualified, and whose business brings him into closer relations with such economic problems? The question of monetary compensation, the sordid matters of dollars and cents, may be left to the business corporations and the courts of law.

CHAPTER II.

DIFFERENT METHODS FOR ESTIMATION OF LOSS OF THE EARNING ABILITY FROM OCULAR INJURIES.

§5. *Zehender's Formula.*

Zehender was the first who tried to make a rule for the estimation of the loss of the earning powers from ocular injuries (53.) His publication provoked a series of papers by other German writers who declared that his premises were incorrect and his calculations illogical. We, therefore, give a critical résumé of the several methods of mathematical computation that have been proposed, showing their errors, and then proceed to the exposition of the method of Magnus, which for accurate scientific work seems to us to be the most satisfactory. Zehender gave a formula founded upon a suppositious case where the sight of one eye is entirely lost while that of the other remains normal. He supposed that such a normal eye acquires a much higher value (even double) than formerly.

To compute the amount of vision left after the loss of one eye by his method, three eye values must be considered, two for the normal eye and one for the blind one, which he places in the form of an arithmetical equation thus, $\frac{2\times1+0}{1+1+1}=\frac{2}{3}$. The visual faculty in such a case is, therefore, two-thirds of normal.

If Zehender's supposition be right and if after the loss of one eye, we really had to figure with three quantities, there would be nothing to say against its correctness, but it is arithmetically incorrect in its conception, for, if we double the value of any object, we do not make by this manipulation two different ones but one which is only of a different value and therefore by such an equation applied to eye values we only change the quality of the two eye values, the number remaining the same. Although this fact may be self-evident, we will exemplify it as follows: Supposing a man owns a house which through some fortunate event would become twice as valuable as formerly, would anybody believe in this case that the man now owns two houses? Let us vary this example and suppose that this man owns two houses of equal value, one of these increases in value to double, the other through some accident depreciates entirely, would anybody conceive the idea that this particular man now owns three houses or claim that he would have to figure with three houses in the valuation of his property? Zehender however has come to such a curious conclusion, so that, by his formula, we would have to figure, in the case of the one-eyed man, with three eye values. He has made a one-eyed person

into a three-eyed one. Zehender's error is in supposing that he really creates by the enhanced valuation of one thing, a new and second self-existing object. Thus, if we would express the earning ability by his speculative proposition and arithmetical example, but avoiding his serious mathematical and logical errors, the formula would be: $\frac{2+0}{1+1}$. But, as this formula would give for the earning ability, notwithstanding the loss of one eye, the full value of one, the consequence is that Zehender's expression cannot be used in the proper mathematical way. Thus Zehender's formula belongs only to history. Nevertheless, he should be accorded the honor of having first shown that the mathematical method is the correct way for estimation of the ocular earning ability.

§6. *Groenouw's Formula.*

(a) Groenouw (12, p. 34) uses a formula which likewise does not give the normal physiologic and economic value for vision, but like that of Zehender's, it rests upon a pathologic process of injury to the faculty of sight. He begins with the supposition that the stronger eye possesses a greater economic value than the weaker one. If the difference of the visual powers of the eyes be somewhat great, then the better eye would alone be accustomed to work while the weaker would count very little in regard to earning ability. Groenouw expresses this supposition by taking first an arithmetical proportion of the visual power of both eyes, $\frac{\text{SE} + \text{se}}{1+1}$ in which SE stands for the better and se for the poorer eye, and by this formula the better eye (SE) is given M times greater value than the poorer one. We would therefore transpose the foregoing formula into $\frac{\text{M} \times \text{SE} + \text{se}}{\text{M} + 1}$. He also adds to this expression the value of the visual field P making the expression for the earning ability, $\text{E} = \frac{\text{M} \times \text{SE} + \text{se}}{\text{M} + 1} \text{P}$.

As Groenouw's formula does not represent the value of normal physiologic vision for earning purposes but rather the value of an already pathologically changed faculty, therefore, it cannot be used for a general expression of economic vision but only for some certain special case. In Groenouw's equation E stands for the earning ability which is the unknown quantity and the results to be sought by all the equations considered in this book. M stands for the greater value acquired by the sound eye after injury to its fellow. This enhancement is likewise unknown. SE is the central visual acuity of the better eye which can be ascertained by functional examination. se is the visual acuity of the poor eye which is likewise to be found. P is the value of the visual field which can be ascertained. We have now in Groenouw's formula an

equation with two unknown quantities, E and M, and three known quantities, Se, se and P. But such an equation has numberless solutions, as it is possible to compute from the values given to one unknown quantity separate values for the other (the exceptions are only the so-called diophantic equations which cannot be considered in this connection.) As this formula admits of numberless solutions we may therefore consider it inapplicable for our purpose, for we would be unable to tell which of the numberless possibilities would be the right one in a given case. An equation which is able to give a single precise answer is the only practical one. Thus, from the very start, with his equation containing two unknown quantities, Groenouw got into a desperate position because he proposed a formula which cannot be treated in a correct mathematical manner.

(b) The estimation of ocular damage by Groenouw's formula in the original form, $E = \frac{M \times Se + se}{M + 1} P$ is not possible, because the two unknown quantities contained therein cannot be figured out of this one formula. Groenouw, however, extricates himself out of this disagreeable situation by forcibly pressing his formula into a more desirable form, which allows of a certain kind of estimation of the damage to central and peripheric vision. Before we can take up the subject of these cases in which there is partial damage to the visual faculty but no actual blindness, we must first regard the working of this formula in the case of a one-eyed man.

(c) We are of the opinion that Groenouw's formula cannot be properly used in the case of monocular vision: For he conceives that there is a certain proportional value between the power of sight in the better and that of the poorer eye, the better eye having M times earning value over that of the poorer (12, pp. 35, 36, 37), *i. e.*, that the better eye (13) exercises an M times greater influence upon the earning ability than the poorer, but if one eye is entirely blind, this proportional valuation is simply impossible because a blind eye is never of any assistance to the earning ability and does not, therefore, possess an earning value: then the poorer eye cannot have an M times greater value than the blind one, for the earning value of the blind eye is equal to nothing, and M times this is also nothing: therefore, the mathematical rule which shows that the multiplication of a number value with naught makes it always become naught, renders Groenouw's calculation a mathematical absurdity, in that according to his rules a one-eyed person must be entirely incapable of earning anything.

In Groenouw's formula E, the earning ability, and M, the enhancement of the earning value of the better eye, is unknown. Se, the sight of the healthy eye, equals 1; se, the sight of a totally blind eye, disappears entirely out of the formula; P, the visual field, is given by him a value of 9-10, which has been found by exact

physiological examination and which we will here accept in a case of monocular vision, Groenouw constructs the following formula:

$$E = \frac{M}{M+1} P.$$

This formula is constructed in an arithmetical equation similar to that of Zehender's. As long as both eyes could see, the better eye with the power SE would have M times value over and above the poor eye, se, thus the numerator of the arithmetical equation would be: $M \times SE + se$. But if one eye grows blind, its faculty of seeing is then entirely omitted, the numerator then becomes $M \times SE$ or because SE is 1 it equals M; the simplified formula thus being:

$$E = \frac{M}{M+1} P.$$

If the value se, one of the two values out of which the arithmetical proportion is formed, is entirely omitted, its influence is exerted not only in the numerator but in the denominator of our fraction. Thus the numerator of the formula would be reduced to $M + 0$, as the numerical earning value of the blind eye is 0. Whether a blind eye is in the head or has been removed by an operation is entirely foreign to this subject, as, if it is blind, it must be regarded as non-existing as far as it relates to the earning ability and must be treated accordingly in the denominator of the arithmetical proportion, which is, therefore, $M + 0$. Groenouw, however, calls the denominator $M+1$, whether one eye can be counted or not, and thus in the formula which should represent solely the physiologic earning value rates a blind and therefore non-existing eye with a positive earning value of 1.

Groenouw has confounded the physiologic with the anatomic conditions; for the physiologic purposes a blind eye is practically the same as if it were non-existing, and because he has done so he presents in the further course of his calculations with human beings who have theoretically nine seeing eyes, for instance, in a concrete case in which one eye has visual acuity of $\frac{3}{4}$ and the other $\frac{1}{4}$, the earning ability is expressed thus: $E = \frac{8 + \frac{3}{4} + \frac{1}{4}}{9} 1$, and this is nothing else but the arithmetical proportion of the faculty of vision of a being who has *nine* seeing eyes. The outrage upon common sense is none the less if the human being be likened to a cyclops or to a nine-eyed monster. One of the two suppositions has to be chosen if Groenouw's formula be used, because it does not admit of the consideration of a normal being having two seeing eyes. We have shown that the text of Groenouw's formula is erroneous and will now regard the manner in which he uses it to express the earning ability of the one-eyed person, for which his formula is,

$$E = \frac{M}{M+1} P.$$

In this formula E and the enhancement of value of the sound eye, M, are unknown. Here is again an equation with two unknown quantities which has no fixed but numberless solutions. Such mathematical difficulties are passed over by Groenouw in the following manner: He first supposes that the income of a one-eyed person is 33 1/3, therefore the earning ability must be 2/3, and without any reflection he inserts this arbitrary value into his formula thus: $2/3 = \frac{M}{M+1}\ 9/10$. In this equation M can be figured without any difficulty, which would be about 3. But we can, of course, have as great a number of values for M as that for E, but for which Groenouw has made an arbitrary valuation, 2/3 or 4/5 (7, p. 35), and which anybody has the privilege of changing. If we would figure by his method, we would form such a fluctuating equation that E could not be mathematically considered.

(d) Groenouw further handles these doubtful and fictitious values in the following way: For the estimation of injuries in which the central visual acuity has been injured, but total blindness not resulting: Here he does not hesitate to generalize the values for M which he forced into his equation in the case of one-eyedness and uses them in the calculation of other cases in which both eyes see, despite the fact that the value of the vision in the seeing eye in one-sided blindness is quite different from that of the better eye in another case where some sight remains. The earning ability of a one-eyed person is quite a different thing from the earning ability of a normal being, and these terms are not interchangeable. Thus, Groenouw's formula, being based upon fictitious values and improperly formed, cannot be used for the scientific estimation of the economic value of vision.

§7. *The Formula of Heddaeus.*

Heddaeus (18) bases his calculations upon the indisputable fact, that if the faculty of sight be reduced to one-half, the remainder represents a proportional greater amount of earning ability than that which has been lost. This observation causes him to suppose that the loss of earning power is equal to the square of the loss of vision. We cannot see why only the square and not the cube or the fourth or any other power should not designate the above proportion. This is simply an arbitrary decision of Heddaeus and is not founded on the real proportion. In his writings, he does not give any mathematic, physiologic or economic proofs of the correctness of his proposition. Heddaeus makes one assertion to which we must most emphatically protest, for he brings the factor of binocular vision in connection with ocular injuries into a most unwarrantably prominent position. In the case of acquired monocular vision from accidents, he asserts that the diminution of the earning ability is only affected by the loss of binocular vision and

that this factor and the loss of the power to estimate distanees eorreetly, is the most essential faetor for the loss of the earning power. This supposition is ridieulous! Although, immediately after the loss of one eye, the faculty for estimation of distanee and size of objeets is lost for a while, and is detrimental to the earning ability, and therefore should not be underestimated, it disappears entirely in a comparatively short time.

By examinations (Magnus 26, p. 38) of the one-eyed laborers among the iron and steel workers in Silesia, it was found that fully 70 per cent. of those who were blinded in one eye had learned to see easily and estimate distances correctly. As this faculty is restored to every one, it needs only passing eonsideration.

CHAPTER III.

§8. *General Principles for Estimation of the Relations of Ocular Injuries to the Earning Ability.*

The fact, that during the last few years so many different propositions for the estimation of the economic value of vision have been proposed, shows that the general principles involved in determining the earning ability are not yet clearly understood. We will, therefore, search for and explain certain general principles for this estimation which will serve as a basis for that relating to the visual act which is one of the functions of the general organization. We will give the visual earning ability a prominent part in our considerations.

If in a given case we desire to mathematically determine the amount of power of any bodily function, we first have to find a general expression for the normal ability of the particular organ. We usually determine such expression by taking the average of a large number of measurements of the particular function and designate this average as an expression of the normal powers. In this way we have formed the standard of visual acuity, of the visual field, of the normal light and color sense, etc. Starting from this average value, we measure the power of the organ in any special case. The difference between its power and our standard is a fraction which in the case under examination may represent the amount of damage done to the function. This we do in the estimation of the pathologic diminution of central visual acuity and with limitations of the visual field. When we succeed in creating such an average normal value of the function of an organ or bodily power, we can then estimate the amount of individual acts, as if measuring a piece of cloth with a yard-stick. This method is used in the other natural sciences as well as in medicine. Therefore, we must first fix an expression for the normal ocular earning ability before we can estimate the amount of individual cases. The objection that the application of this principle to the act of vision and the resultant measurements would be arbitrary, holds good to but a limited extent, for where a conception of the normal function has been developed from a series of definite measurements from which the average value has been estimated, we do not speak arbitrarily, especially where this conception has been upheld by other findings, the products of searching inquiries of a scientific character; but we must remember that a function of a body or a natural power is a need which cannot be weighed with the scales or measured by the yard, and therefore we cannot entirely do without certain arbitrary suppositions.

In our opinion *there is only one way for the establishment of a formula for the normal ocular earning ability, and that is, by the separate estimation of the value of each physiologic factor forming the sense of sight, and by the addition of these component parts the normal value of vision may be established.* The construction of such a formula is facilitated by the fact that we already have established the physiologic value for the more important factors entering into the visual act, *i. e.,* the central visual acuity and the field of vision. But the normal physiologic act of vision is a composite quantity formed of different factors which have more or less relation to the economic value of the eye. We may exclude those factors which are without economic importance for the sake of our subject. We thus form out of the composite act of seeing a reduced or economic estimation of the visual act. In order to do this we must fuse, bring into or eliminate certain of these factors to satisfy our purpose. As we have placed the visual earning act in a normal position (chap. IV., § 9), we will use the same method for determination of its factors. Damaged ocular earning ability will always be considered as a fraction of the normal power. This method, which permits of a mathematical estimation of each portion of the visual act as a fraction of the normal, must be considered to be complete, as it is in perfect harmony with the principles laid down by the natural sciences in measuring the work of any organ or power.

Judging by this standard, we must consider that the propositions of Zehender, Groenouw and Heddaeus were on the wrong track from the very start. None of these authors developed an expression for the normal physiologic act of vision. Their formulae for expressing the economic value of vision stand absolutely on pathologic grounds and they introduce self-constructed pathologic suppositions into the calculations, instead of looking at the earning ability as a quantity resulting from a combination of the different parts composing the physiologic act of vision. Thus these formulae are not expressions for existing conditions, but are nothing but the mathematical sediment of intuitions arbitrarily conceived by these authors. As they have departed from the physiologic and only reliable ground for arbitrary hypotheses, their theories are shown to conflict, in a most humorous manner, with the physiologic ocular conditions in a healthy person. Thus, according to Zehender's calculation, a human being would have three seeing eyes, and Groenouw acts as if nature had given him nine eyes or put him into the world as a cyclops.

CHAPTER IV.

THE CONCEPTION OF THE EARNING ABILITY AND INJURIES THERETO.

§9. *The Meaning of Full Earning Ability.*

If we would conceive of an injury to the earning ability as a quantity which can be given a mathematical value, we would have to start from an estimation of the complete earning ability, which in a healthy normal individual is a composite quantity resulting from three factors:—

(1) The unimpaired functional power of the bodily organs.

(2). The technical knowledge which is necessary for the carrying on of the vocation.

(3). The ability of the individual to compete in the labor market.

In an opinion given by the Imperial Insurance office Nov. 26, 1887 (Becker 5, p. 10), the meaning of the earning ability is thus stated:

"In judging the earning ability the bodily and intellectual condition of the injured person has to be considered in connection with the preparatory education and also his capacity for earning a living." In this definition, "bodily and intellectual condition," is the same as the first of our elements (1), the unimpaired functional ability of the bodily organs; the so-called "preparatory education," would correspond with our (2), the technical knowledge necessary to the calling; and our (3), the capacity or ability to compete in the labor market, is defined in the official definition as "capacity for earning a living."

These elements cannot be regarded as equal in value. Doubtless the functional condition of the bodily organs is of the first importance for successful work. The preparatory education or knowledge is of nearly equal value. Much less importance should be given to the third element, the ability to compete in the labor market. This is dependent upon the value of the two others, because the ability of an artisan to battle against competition depends largely upon the condition of his health and his technical knowledge—our two first elements. We have divided the conception of the earning ability into its three fundamental elements solely because such an analysis makes it possible to put the normal earning ability into a mathematical formula. Thus we designate the earning ability itself E; the first of our elements, the functional ability, F; the second, the necessary knowledge, V; and the third, the ability to compete, K. In this formula we put the two quantities, F and V, in their full value and accept K as a root

value. There would be nothing changed in the total value of the formula itself because as the root of 1 is always 1, and we regard F, V and K as 1, it is immaterial for the formula itself if we take one of the three quantities as a root or not, but this proportion immediately changes when the part introduced as a root grows smaller than 1, as happens in each ocular injury, because the root of each genuine fraction is always greater than the fraction itself. Thus the influence of K, after being introduced as a root value, if it has fallen off by an injury to $\frac{K}{z}$ cannot be any more $\frac{K}{z}$ but must be greater, for instance, $\frac{2K}{z}$. Therefore, the damage to the total value of the formula will be smaller if we take K as a root value. By the total elimination of K the earning ability will not be diminished, but it will be by a smaller damage, according to the influence the damage of K shall exercise upon the value of the total formula. We will have to choose the exponent of the root as smaller or greater, according to its rating. The value of a root of a genuine fraction is much greater if its exponent is small. Therefore, if we wish to lower it considerably, we take a small, if we wish to effect it less, a greater exponent for K. While the ability to compete, K, is comparatively very little impaired through minor ocular injuries, it is very much so through the loss of one eye; we suit these conditions by choosing a greater exponent of the root in slight injuries, but a smaller exponent for serious ones. We will adopt for the slight injuries K as the 10th root and for serious ones according to the demands of the profession, the 7th root or the 5th root. We will more fully explain this in one of the following chapters. An exact calculation of such a changeable quantity so dependent upon the individual cannot be made. The calculation of the competing ability cannot be waived entirely, as does Groenouw, who submits in each case the estimation of this important factor to the pleasure of the examiner. We have started out to make a practical mathematical formula, but should include all factors that are relative; as we will show further on, the peculiarities of the individual case may always be considered.

When we express the earning ability through the three factors, F, V and K, we present E, not as a sum, but as the product of these quantities, as multiplied thusly: $E = F V \sqrt[x]{K}$, in which the exponent x changes with the degree of the functional damage. E must always be regarded as a product and not as a sum, to meet all possibilities occurring in practice. If we add F, V and K, the formula would give wrong practical results, as we see in the following example: Supposing both eyes were lost in an accident, the quantity F of our formula would be 0. If we had connected F, V and K with the +, and added, even if K would have become 0, $V + \sqrt{K}$, which is the remainder of the earning ability, would have been left.

This would be entirely wrong, because a laborer who has lost his functional ability, especially the sense of sight, should be regarded in an optical way as entirely unable to earn. Taking the same example and using our formula with F=0, E immediately becomes 0, because each product is always 0 if one of the factors is 0. If we would leave V out of our formula, E of course = 0, and actual practice confirms this, because even the most simple hand work requires a certain amount of preparatory education. Finally, if we drop the third factor, the 10th root of K, the normal earning ability according to our formula becomes 0, which is likewise shown by practical experience, because, even though an individual is in good health and by reason of preparatory education has the skill to work, if his work is not needed, his economic value is nil. He may possess the power of working, as the factors F and V are present, but he only has earning ability when he can dispose of the work in the economic market. Therefore, if from our formula ($E = F\ V\ \sqrt[x]{K}$) we take away the factor $\sqrt[x]{K}$ (the ability of the individual to dispose of his work), the remainder, which is the formula for the working ability (A), would be $A = F\ V$.

The "working ability" is not synonymous with "earning ability," although some authors would have it so, for instance, Becker (5, p. 9): "The words 'working ability' and 'earning ability' may be regarded identical in meaning, because in each worker the latter depends upon the former." Even if this be so, the two conceptions are not the same, and such a rendition obscures the conception of the earning ability, our definition of which should be clearly understood.

The calculation of injury to the earning ability proposed by us starts from the formula for the *full earning ability*:

$$E = F\ V\ \sqrt[x]{K}.$$

CHAPTER V.

§10. *Determination of the Amount of Injury to the Earning Ability According to Magnus.*

When one or more of the factors forming the earning ability is injured, an idea of the amount of damage to it may be formed if we first consider to what extent the single factors are injured. We will find that the application of mathematics to this subject will prove somewhat complicated, as we will have to first separately estimate the damage to the different factors and then fix the value of the total formula. Under certain conditions, this task may become decidedly complicated, as some of these factors forming the complete earning ability are composed of several elements which have to be figured separately. This is especially the case with the act of seeing (F of our formula), which, as we will see directly, consists of three separate parts, each of which may be damaged in a different way. To ascertain the value of the factor F, we have to solve three mathematical problems, but in return, our method of estimation does not alone offer the possibility of giving a mathematical expression to the different forms of damage to the ocular apparatus, but also allows us to do this in an accurate manner, with due consideration of the different individual conditions in question, and finally our method solves the mathematical problems (chap. III, §8) in a satisfactory manner. It starts from the physiologic ocular earning ability and designates the damage thereto as fractions of the normal value, making our method right in its principle and easy to comprehend. The calculation of our formula is simplified by the fact that our factor V (the preparatory education), may be entirely cut out in estimating injury to the earning ability. As important as this factor may be to the normal earning ability, we may put it aside in a case of accidental damage. The technical education in itself will not be injured directly. It is only indirectly affected by accidental injury. Certainly the visual function may be diminished to such an extent that the realization of the technical knowledge becomes limited, but this injury to the earning ability in such a case does not rest upon a diminution of the knowledge and the capacity, but limitation of their use. We calculate the extent of such limitation, according to our method, directly by the factor F, *i. e.*, from the performance of the visual act, which is the essential factor in the full earning ability, damage to which is synonymous with damage to the total. Calculating F we have already used V. For simplicity's sake it would be better to omit V entirely. The *working formula* for the earning ability then would be: $E = F \sqrt[x]{} K$.

CHAPTER VI.

§11. *Estimation of the Damage to Economic Vision.*

Normal physiologic vision consists of a series of different factors: the central acuity, the visual field, light and color senses, the adaptive faculty, the muscular movements and the cerebral processes, all acting together in creating the sense of sight. We may, therefore, regard the act of seeing as a sum whose numerals are formed by the different functions; if one numeral be taken from the sum which represents the complete act of seeing, then the balance will be left, *i. e.*, vision will be damaged to the extent of the loss of one of these visual functions; but vision is yet in existence in a limited way. In the manufacture of a formula for physiologic vision we would have to consider that in losing simultaneously the two most important factors, central and peripheric vision, the act of seeing would be nil; but from an economic standpoint we could not get along with this idea. The different secondary functions forming sight have different valuations. In calculating the injury to the visual earning ability we will have to exclude cerebral vision because accidental injuries affecting the cerebral centers will hardly ever be of such limited extent that the valuation thereof would be done by an oculist. In such a case the neurologist would be demanded. The sense for light and color and that of adaption are not themselves to be considered in estimating accidental damage to the ocular earning ability. An injury limited exclusively to these functions is not known. Theoretically such injuries might be possible, but practically they are not recognized. Such traumatisms would generally be connected with disturbance of other portions of the visual act, especially that of visual acuity and the visual field. Therefore, we include the functions of the light and color sense and of the adaptive power, when we treat of the disturbances of the visual acuity and visual field, as thereby the estimation is rendered less complicated. The visual acuity, the field of vision and the muscular movements are of so much more importance that we think we can properly estimate the results of ocular traumatisms by taking into consideration only these latter three. These are to be regarded as the factors of a product and multiplied. Practical experience shows us that we must do this under all circumstances, because for the following of a vocation, none of these factors could be damaged or left out, for without them the earning ability would disappear. If a person loses the central acuity of both eyes, then we certainly have complete earning disability; not even the common laborer having lost his central acuity could do his former work. Such an individual could only take very low grade positions, such as that of a messenger. The possibility of

doing much work in the several trades after the loss of central acuity is so completely excluded from consideration, that it would be extremely incorrect if we did not consider an artisan who had a large central scotoma, *i. e.*, lost his central visual acuity, entirely unable to pursue his vocation and earn anything. If peripheric vision is lost in both eyes, working at trades is likewise excluded, as is readily seen in cases of double-sided hemianopsia. A working man with total paralysis of all the outer ocular muscles is likewise totally disabled. In such a case he will stare into vacancy and cannot work in a binocular manner. He would lose the ability to estimate distances and the size of objects, and could only have a certain degree of monocular vision, which could be imagined to be useful only in certain special cases, as that of a nearsighted clerk. Such a case might be looked upon as a curiosity and would be rather an exception, so that it could not be used to refute our view that the ocular muscles are absolutely necessary for the earning ability. Even the closing of one eye, which Groenouw holds in readiness as a remedy for the restoration of the earning ability, will help nothing, for the other will stare immovably if its muscles are paralyzed. The adjustment that is noted in congenital defects cannot be likened to that of acquired ones and cannot be considered in their influence upon the earning ability. The physiologic process out of which an adjustment and an increase up to the earning ability, which has been asserted by Groenouw (13) to have occurred in a case of acquired paralysis of all the ocular muscles, is certainly very strange to us. Therefore, in the case of an artisan with an acquired paralysis of all the outer ocular muscles there is total disability to work.

In building up a formula for the act of seeing in relation to earning, we denominate the central acuity with the letter C and the visual field with P. The valuation of the muscular motions, M, offers certain difficulties, because the influence of a disturbance of the function in a single ocular muscle, from a professional standpoint, is quite a different one, whether we take into consideration monocular or binocular vision. The monocular act is but slightly affected by paralysis of one ocular muscle, as it only diminishes the motility of the eyeball, but in binocular vision the factor of diplopia comes in and this is of the greatest importance, as it excludes, temporarily at least, retention of working binocular vision. In formation of our formula we would, therefore, treat the factor of muscular movements in a different manner, when treating of binocular vision, than we would for the monocular act. In the formula for binocular vision we take the muscular movements of each eye as the product of different factors, each of which corresponds to the activity of a particular muscle. Now, if we mark the muscles of one eye with (m_1 m_2 m_3 m_4 m_5 m_6) and those of the other (m_1' m_2' m_3' m_4' m_5' m_6') etc., we would represent

the whole muscular activity as (m_1 m_2 m_3 m_4 m_5 m_6) (m_1' m_2' m_3' m_4' m_5' m_6'). In this conception the whole product would be 0, by losing one single muscular motion, and therefore the binocular act would be negative. In monocular vision the muscular activity should be conceived as the sum of the single performances, because by losing one of them only an ocular detriment has been created and not total earning disability, thus $m_1 + m_2 + m_3 + m_4 + m_5 + m_6$.

A few remarks about the relations of the different factors entering into the visual act are here advisable. The central visual acuity is, under all circumstances, the most important element for the function of vision. Any injury which reduces the central visual acuity below the lowest limits required in the profession, produces a total disability for that work. Peripheric vision is of less importance and has not as much influence upon the visual act, and injuries to it have a smaller influence to the entire act of vision than the degree of injury of the visual field itself. If, for instance, the remaining peripheric vision, P, should be denominated with a greater fraction than $\frac{Y}{X}$, we may do this by introducing P as a root value like we did with the factor K for the earning ability (Chap. IV, § 9). The root of $\frac{Y}{X}$ would then be greater than $\frac{Y}{X}$, for instance $\frac{2Y}{X}$. The damage to the total value of the formula would be smaller, if P be taken as a root value and the value of the act of vision would not be diminished to the value of P, but to a smaller extent.

The same is the case with the action of the muscles, but even to a greater extent, as they are much less important for the monocular act of vision than is the visual field. We will, therefore, add the action of the muscles M as a root value in the formula, but we will take the exponent of this root to be much greater than the exponent of the root value of the visual field. According to mathematical principles the value of the root of a proper fraction increases with the amount of its exponent, thus, if we introduce M with a greater exponent of the root than P, in the case of damage to M, it will exercise less influence upon the total value of the formula. We believe that we may place the relative value of the visual field and the muscular movements by choosing as exponent of the root in the former 2, and in the latter 4. Of course, these are arbitrarily chosen, as it is an undisputed fact that the central visual acuity, peripheric vision and the muscular movements have different meanings in the act of vision, the proportional valuation of which cannot be put into figures from observation nor from measurement, it is certainly allowable for the mathematician or the physician to estimate the amounts of these exponents differently, but the formula itself will not be changed. We thus reserve for the

examiner in each case, the right to make allowance for his individual conception, which factor we regard as a great advantage in our method. Thus our formula for the *binocular act of vision* would be: $S_2 = C\sqrt{P}\sqrt[4]{(m_1\, m_2\, m_3\, m_4\, m_5\, m_6)\,(m_1'\, m_2'\, m_3'\, m_4'\, m_5'\, m_6')}$

In this formula C is considered the central visual acuity in the better eye, which under normal conditions will always equal 1.

In case of double-sided damage to the visual acuity, if we desire to condense this formula into that for the monocular act, we should consider that the peripheric vision as well as the activity of the extra ocular muscles M, enter into the monocular act in a somewhat different form. The monocular field of vision is a fraction smaller than the binocular. It is commonly only $\frac{5}{6}$ (Groenouw $\frac{9}{10}$) of the latter. (An exhaustive explanation of these conditions will be found in the chapter treating of monocular vision.) The extra-ocular muscles have smaller value in monocular vision than in binocular, because in the former those functions of the outer musculature of both eyes that are essential in estimating distance and the relations of objects, etc., are missing. Therefore, we here consider the value of the musculature as less and estimate it at $\frac{2}{3}$ of the binocular value. This smaller valuation of M may be ultimately neutralized if a monoculism caused by accident has existed a considerable period. We compute the formula for *the monocular act of vision* from the binocular one as follows:

$$S_1 = C\sqrt{\tfrac{5}{6}}\,P\sqrt[4]{\tfrac{2}{3}\,(m_1 + m_2 + m_3 + m_4 + m_5 + m_6.)}$$

§12. *Estimation of the Economic Limitations of the Central Visual Acuity.*

The central acuity lies within well-known physiologic limits. When it falls below these, the function itself is damaged, but the conditions met with in practice are not such that the physiologic and earning limitations of the central visual acuity are interdependent; if it were so, the claim of Zehender (53, p. 266) would stand; then the smaller the damage of the former, the greater the earning value of the latter, and *vice versa*. If we desire to have a general rule for the ability of every single ocular function, an average value must be found by many single measurements, but such average values permit of many exceptions and cannot be designated as the average limiting value of the earning ability, for, if such were the case, each variation therefrom might be termed a damage to the earning ability. This may be done by individual measurement of each factor in each case, but such always bears an individual stamp. We must not forget that while the limit values of every function have a scientific meaning, the conditions met in actual practice are different. Science calls an individual blind only when perception of light has entirely disappeared, but in actual practice, he is blind if the faculty of sight has been weakened to such an extent that

the organ of vision cannot be used to earn a living (Magnus 24). The meaning of blindness as used in daily life is much narrower than that of science.

Now and then extremely great demands may be made upon the action of certain organs which may reach to its highest ability. In actual practice we are satisfied with the amount of labor which does not strain the powers. Zehender's (53, p. 266) principle, that the full earning ability existed only with full acuity of vision and every diminution of the highest limits means at the same time a diminution of the earning ability, cannot be accepted. Not alone do we raise scientific scruples against the acceptance of a proportional relation between the earning ability and the scientific meaning of visual acuity, but also practical experience is entirely against such relation. There is hardly any vocation which demands the extreme limit of sight (according to scientific figures), as a condition of success. In each vocation a great many individuals may be found who have comparatively poor sight but the same earning ability as those with normal eyes (Groenouw 11). Josten (20, p. 526) is correct when he says that Zehender shifted with his principle not alone the limits of the earning ability, but created a new and artificial meaning. Neither the lowest nor the highest points of scientific visual acuity correspond with that used in business; the lowest point of the latter is not as low as the lowest point laid down by science, while the highest point of the functional range that may be regarded as normal, must be considered greatly below the highest scientific limit. The highest as well as the lowest demands of the different professions upon the central acuity differ greatly and we have no proper standard for their exact numerical estimation.

Groenouw has proposed that it would be suitable to gather exact observations concerning the minimum of visual acuity sufficient for a certain vocation by examining the vision of workingmen in different factories and comparing the same with the work done on the wages earned. We would certainly gain a knowledge of what functional qualification may be necessary in a certain trade, but we do not believe that we can gain an exact knowledge of the lowest demands of the different professions upon the ocular functions, as we can only find out by such examinations the case which has the lowest vision and how high is the earning value of this vision. So that, if among the personnel of a certain trade one workman with a visual acuity of $\frac{1}{4}$ has been able to earn a living, it may be possible that in the workmen of another factory a still lower acuity of vision, even $\frac{1}{5}$, may have allowed a certain individual to earn a living. But, if by exhausting the complete examinations of large numbers, we have eliminated the probability of finding lower values, even this might not preclude the possibility of finding the very lowest degree of vision which is sufficient for this particular trade.

kind of work the individual may follow. In the case of a day laborer whose visual functions are not much taxed in his work, the sudden reduction of whose vision to ½ the normal would probably not prevent his working, but if the vision of a skilled mechanic should suddenly be reduced to ½, he will certainly have to stop, as he is used to work with clear retinal impressions. In acknowledgment of these conditions, the courts have lately given opinions in which the demands of the particular professions have been considered. The German Imperial Insurance office (3, p. 250) seems to favor such principles.

Considering the above, it is advisable to give movable boundaries to the economic limitations of vision. Let us accept the maximum limits as between ¾ and ½ of the normal scientific standard for the visual acuity and in the following our estimations will be made with these two values. The lowest professional limit of visual acuity is not in concurrence with the minimum scientific limit, for when the acuity of vision sufficient for working purposes has ended, there still remains an acuity that may be judged by the scientific standard. Zehender's proposition (53, p. 268), where he considers the lowest limit value of the professional acuity as $\frac{1}{100}$ of the normal scientific value of vision, cannot be supported. Professional work is impossible with only $\frac{1}{100}$ of the normal visual acuity. We would regard even a far higher degree of acuity as too low and believe that a standard for complete inability to earn should be fixed at $\frac{1}{20}$ of the normal visual acuity. In many cases even this limit of $\frac{1}{20}$ would be too low, because there are vocations in which a higher limit than $\frac{1}{20}$ would be insufficient. Silex (39 separate edition, p. 6) thinks that in certain branches of the railroad service and in certain other trades or professions a visual acuity below $\frac{1}{6}$ would be insufficient. It is, therefore, advisable to make the lowest economic limit of visual acuity a movable one and not to fix an unchangeable value. We therefore adopt for the lowest economic limit of the visual acuity two values, 0.05 ($\frac{1}{20}$) and the standard of Silex, 0.15 (about $\frac{1}{6}$ or $\frac{1}{7}$ of the normal visual acuity).

Out of these four limit values the two maximums (0.75 and 0.5) and the two minimums (0.15 and 0.05), we may construct two ranges within which the professional or economic limits may lie. One of these spheres or ranges would have as its highest limit 0.75 ($\frac{3}{4}$), as the lowest 0.15 (about $\frac{1}{7}$), while the other range would be between 0.5 ($\frac{1}{2}$) and 0.05 ($\frac{1}{20}$) of the normal scientific standard for visual acuity. It is not necessary that the said maximum and minimum limit values exist in both eyes; it is sufficient that they be shown in one eye, the other having a lesser acuity than that which we have declared as absolutely necessary for professional optic demands. We believe that if the second eye in trades having higher visual demands, retains an accuracy of vision of $\frac{1}{2}$, and in those having lesser demands, $\frac{1}{3}$, we may speak, in a professional sense, of "sufficient visual acuity."

The least acuity of vision found would only demonstrate with what small degree of vision an individual could learn a trade or by long practice be able to follow it, but it could not show how low the visual acuity of a former normal person might suddenly depreciate without making him unfit for his trade. Any one entering a profession while young with a certain amount of defective vision may gain by practice full earning powers. The highly characteristic examples given by Groenouw (11) show how much weakness of vision acquired in youth may exist without marring the earning capacity.

There is quite a difference, however, in the case of a person, starting to learn a trade, having congenital poor sight or acquiring it in early youth, and therefore used to indistinct pictures on the retina, and a case of a man with normal vision, accustomed to work with clear retinal pictures, who, after an accident, may have to suddenly depend upon indistinct visual impressions. The same degree of vision sufficient in the former case would not be enough for the latter. It is, of course, possible that in the latter case, long continued practice might finally lead to sufficient recovery of the earning ability and the degree of visual acuity here existent might be considered as the least compatable with the profession. But such a rule could not be made general. For the recovery of a certain degree of the earning ability after diminution of the visual acuity is not dependent upon the will of the individual, but upon other decisive factors. The age of the individual plays an important rôle in this ultimate compensation. A younger man may easily overcome a high degree of disturbed vision and by practice recover the lost earning power; but in an older individual even a lesser degree of visual disturbance will never be overcome. Any intellectually gifted individual will be able to make use of indistinct retinal impressions in his work to a far greater extent than an intellectually dull one. The above factors show that a certain degree of visual acuity would be sufficient in one person for a certain vocation, while another could not work by it.

Although exact figures as to the limits of the working acuity cannot be found by examination of patients, yet certain estimations may be made from experience. Josten (19b, p. 528) refers to the visual limits acceptable for military service. The instructions for military service (8, p. 96) designate a diminished visual acuity to $\frac{1}{2}$ of the normal as, "a small disability which does not destroy the general fitness." A visual acuity in both eyes that is between $\frac{1}{2}$ and $\frac{1}{4}$ is called "conditional"; and if it is $\frac{1}{4}$ or below, it is called "absolute unfitness." Josten (19 b, p. 528) adopts the military standard to business life as follows: "Diminution of the earning ability does not take place if there is $\frac{1}{2}$ the normal visual acuity in both eyes." But, although this proposition of Josten is very simple and acceptable, yet in certain cases a shifting of the visual standard above $\frac{1}{2}$ is necessary. This depends upon the

According to this standard we submit tables which divide the followers of the different manufacturing vocations into two groups:

TABLE A.

THE VARIOUS TRADES AND PROFESSIONS ARRANGED ACCORDING TO THEIR VISUAL DEMANDS.

GROUP I.

Trades requiring higher degrees of visual acuity. Range 0.75 to 0.15 (scientific standard).

The higher professions.
Medicine.
Theology.
Law.
Art.
Engineering.
Students of all professions.
Fine mechanics.
Iron and steel workers.
Rolling mill workers.
Machinists and metal workers.
Precious metal workers.
Musical instrument makers.
The linen industry.
The textile industry.
The silk industry.
Paper workers.
Leather workers.
Garment makers.
Printers.
Marine employees.
Railway and steamship employees (including city roads).
Soldiers and sailors.
Telegraph operators.
Skilled labor generally.

GROUP II.

Trades requiring lower degrees of visual acuity. Range 0.50 to 0.05 (scientific standard).

Glass blowers.
Mine workers.
Quarry men.
Builders.
Pottery makers.
Brick makers.
Workers in mechanical industries.
Employees in gas and water works.

Paper makers.
Wood workers.
Mill employees.
Manufacturers of food articles.
Sugar factory employes.
Brewers and maltsters.
Tobacco workers.
Chimney sweeps.
Street railway employees (horse cars).
Employees of elevators and wine cellars.
Teamsters.
Bargemen on inland waters (rivers, etc.).
Farmers, etc.
Day laborers, etc.
Unskilled labor generally.

Individual members of certain trades do not have exactly the same visual demands made upon them; some under certain circumstances may have much higher and others lower visual requirements. In the course of our work, in certain cases, we must remember this fact and not judge all the members of the some trade by the same standard. The railroad employees have been officially divided into fixed classes, and if the other trades could be so treated, the physician would know exactly into what class he should put the individual case. We do not desire to force our propositions upon the associations, physicians or officials. We desire, however, that the foregoing shall be considered before generally adopted principles be introduced into practice. It is certainly advisable to reach some definite agreement as soon as possible, as hitherto there has been a disposition among oculists to consider only the results of the scientific examination of the visual acuity as the basis for the valuation of the conditions arising in practical life. If the estimation of the result of the amount of damage arising from ocular injuries is to be made in a just manner according to actual conditions, this custom must be abandoned.

Our views regarding the difference between the scientific and working standards of visual acuity can claim far more extensive practical consideration than that which relates alone to the subject in hand of ocular injuries (Chapter XIX). All professions or vocations which make admission dependent upon a certain degree of vision would do well to remember that practical visual acuity and that of scientific standard are entirely different things and that an individual may have, for working purposes, a full amount of vision who by the scientific standard shows a deficit. This fact has been ignored in the past, it being considered that an individual with defective visual acuity according to the scientific standard must have the same defect in his working life. Individuals have been refused admittance to trades on ocular grounds, al-

though if their vision had been measured according to the economic and not by the scientific standard, they could have pursued their vocations. The authors have many times seen how much at variance the purely scientific examination of the visual acuity could be with the demands made by practical work. The management of the German roads have lately taken this into consideration, Magnus' suggestions having been accepted since January 1, 1893, in the Breslau Railroad Company as regards the qualifications of railroad employees. Their requirements do not now include "normal" acuity of vision by the "scientific standard," but only *"sufficient visual acuity;"* the authorities having thus acknowledged that an estimation of the vision required in railroad employes should be made by the practical economic or professional standard rather than that of the scientific. Schmoeckel (36) and Silex (39) have lately divided the employees of railways into two classes similar to our proposition. In these, one eye is to have at least $\frac{5}{6}$ (Schmoeckel) or $\frac{2}{3}$ (Silex) and the other $\frac{1}{2}$; and in the other class one eye must have at least $\frac{2}{3}$ (Schmoeckel) or $\frac{1}{2}$ (Silex) and the other $\frac{1}{3}$ or $\frac{1}{6}$ of the normal visual acuity. Schmoeckel thus divides the different branches of railway employes according to the visual demands made upon them, into the following groups:

Group I.—Without glasses on one eye at least a visual acuity of $\frac{5}{6}$, on the other $\frac{1}{2}$ of the scientific standard: Locomotive employees (engineers and firemen), station employees, switchmen, flagmen, yardmen.

Group II.—With or without glasses on one eye at least a visual acuity of $\frac{2}{3}$ and on the other $\frac{1}{3}$ of the scientific standard: Wipers, wagonmasters, brakemen, guards, conductors, baggagemasters, warehousekeepers, freightmasters, porters, watchmen, despatchers, roadmasters.

The two groups proposed by Silex contain about the same divisions, only he puts brakemen into Group I., whereas they are put into the second group by Schmoeckel.

In America the tendency is to demand the highest visual qualifications from prospective railway employes, the full scientific standard of $\frac{20}{xx}$ (1.0) being required by many railroads and being demanded as essential by the consulting oculists of the principal systems. It must, however, be observed that what we call normal visual acuity is a very relative term, so that $\frac{20}{xx}$, the usual standard, may in a good light be read by a young person with reduced visual acuity, when his real economic standard is $\frac{20}{xv}$, or $\frac{20}{x}$ (Thomson 45, p. 349).

Allport (1) recently inquired into the conditions existent in the United States relative to the vision required of railroad employes, and in response to a circular letter received specific answers

from 64 railroads operating 90,950 miles of road; there being 244 prominent railroad companies in the United States which cover 205,638 miles of road. Fifty-three out of 64 roads exacted systematic eye and ear examinations, about 50 per cent. requiring such examinations of all men directly engaged in moving and operating trains, in giving and receiving signals, such as engineers, firemen, conductors, brakemen, yardmen. signalmen, switchmen, etc. This examination is made by a railway employee, such as the superintendent, trainmaster, etc., and doubtful cases are sent to the eye and ear surgeon. Nine roads have a regularly employed oculist. In three the men are examined by the railway surgeon, and doubtful cases are referred to an oculist. In three the examinations are made by surgeons of Railway Relief Associations. The standard required is various. In 23 it is claimed that "perfect eyes" are required of both old and new employees. In 16 perfection is required in new men and reasonable concessions made to old employees. In one road engineers and firemen must possess of $^{20}/_{XX}$ in one eye and $^{20}/_{XXX}$ in the other; conductors, flagmen, brakemen, switchmen, must have a vision of $^{20}/_{XXX}$ in one eye and $^{20}/_{XL}$ in the other; all others must have $^{20}/_{XL}$ in both eyes. One road demands 75 per cent. of the normal function, etc. This shows that the scientific standards required are decidedly different. We are, however, fast coming to the conclusion that a *practically perfect working or economic standard of vision* should be required for new men and that they should not have any grade of refractive error, such as hyperopia over 2.5 D, which would ultimately render their distant vision poor, as owing to the dust and exposure of railway service, the vision should be normal without the correction of any refractive error by glasses.

Allport (1) divides the railway employees into two classes according to their specific vocations.

Class A.—In which the vision is required to be at least $^{20}/_{XXX}$ in one eye and $^{20}/_{XL}$ in the other, and which must be reached without glasses; distance glasses are not allowed on duty.

Class B.—In which the vision shall be at least $^{20}/_{XL}$ in one eye and $^{20}/_{L}$ in the other, and in which the employee is not only allowed to wear glasses, but is required to do so if the refractive error is such that it is necessary to bring vision up to the proper standard.

Class A.—Engineers, firemen, conductors, brakemen, switchmen, signalmen, switch-tenders and engine-dispatchers.

Class B.—Track foremen, bridge foremen, crossing flagmen, bridge tenders, gatemen, train baggagemen, telegraph operators, station agents and station baggagemen.

Williams (48) makes about the same subdivision of the classes and demands the following:

Class A.—Engineers, firemen. For entrance to the service or promotion, $^{20}/_{XX}$ or average normal vision in each eye, re-examination every three years not less than $^{20}/_{XXX}$ with both eyes open without glasses.

Class B.—For entrance to the service or promotion $^{20}/_{XX}$ in one eye and not less than $^{20}/_{XL}$ in the other and for re-examination every three years not less than $^{20}/_{XL}$ with both eyes open without glasses.

Thus in Germany the application of the full scientific standard to the cases of railway employees has been abandoned and visual acuity of $^{5}/_{6}$ or $^{2}/_{3}$ is regarded as sufficiently high, and, therefore, we may consider this quantity as the normal economic standard or 1.0. As these considerations will be ultimately accepted, it is perhaps advisable to adapt our test letters to the professional standard. This may be easily done on the examination cards now in use, if we would mark the lines on Jäger's types or Snellen's cards (see Plates II., III.), which are equivalent to $^{5}/_{6}$ or $^{2}/_{3}$ of the scientific standard as the full professional acuity for the higher trades and $^{2}/_{3}$ or $^{1}/_{2}$ that for trades demanding less visual acuity. The German Ministry of Railroads (38) has lately divided its employees into different classes as regards their visual demands and has therewith given the examining physician a basis for judgment of the ocular earning ability in the individual case. It would be desirable that the Accident Insurance Companies and Railroads of America and the managements of other vocations demanding specific visual qualifications, would do the same thing with all applicants.

When we have thus placed the meaning of economic visual acuity within materially narrower limits than that which the science of ophthalmology permits, we must not forget that our charts used for estimation of the visual acuity correspond only with the scientific standard. Thus in each case the remaining degree of visual acuity according to the scientific standard found by the physician in the case of the injured person should be transposed into that of the economic standard before it may be used for estimating the damage to the earning ability. This is done in the following table:

TABLE B.

THE SCIENTIFIC STANDARD FOR VISUAL ACUITY CONVERTED INTO ECONOMIC TERMS.

I.

Scientific standard.	Economic standard for vocations demanding higher degrees.
0.75 =	1
0.70 =	0,9166... = 11/12
0.65 =	0,8333... = 10/12
0.60 =	0,750 ... = 9/12
0.55 =	0,6666... = 8/12
0.50 =	0,5833... = 7/12
0.45 =	0,500 ... = 6/12
0.40 =	0,4166... = 5/12
0.35 =	0,3333... = 4/12
0.30 =	0,250 ... = 3/12
0.25 =	0,1666... = 2/12
0.20 =	0,0833... = 1/12
0.15 =	0,000

II.

Scientific standard.	Economic standard for vocations demanding lesser degrees.
0.50 =	1
0.45 =	0.8888... = 8/9
0.40 =	0.7777... = 7/9
0.35 =	0.6666... = 6/9
0.30 =	0.5555... = 5/9
0.25 =	0.4444... = 4/9
0.20 =	0.3333... = 3/9
0.15 =	0.2222... = 2/9
0.10 =	0.1111... = 1/9
0.05 =	0.000

In tables which follow, by which the state of the earning ability in cases of different ocular injuries is estimated, the calculation is always based upon the values altered as above, but as this valuation is not yet generally accepted and the fixing of the acuity of vision is generally done according to the method of Snellen, we have also given the degrees according to scientific standard. It must be remembered that in all our tables the amounts of visual acuity correspond with the scientific values transformed as above into the professional ones. Thus with visual acuity of 0.4, its economic value is not 0.40 but 0.7777 . . , if the injured person has a profession with slight visual demands; but if it requires a higher degree of vision, the scientific standard of visual acuity, 0.4, would be transformed into 0.4166 . . , with which the calculation is made.

We show, figuratively, the relations between the scientific and the economic visual acuities in Plate I. (Frontispiece). In this drawing the degrees of vision in the abscis and the ordinate axis are marked, at intervals of 0.01, so that five of these are always taken together; the abscis as well as the ordinate axis are divided by this into 20 equal parts. The curve of the scientific visual acuity is marked as a coarse black line (I) and because this progresses gradually, it has been equally divided. Economic vision will not suffer very much if the acuity falls off 0.05, because the difference between 1 and 0.95 is so little that it will scarcely be noticed. But, if the acuity falls off further, a point will soon be reached where

every loss affects the working capacity, and if the vision falls below this point, for instance, to 0.05, then it has no economic value whatever, and when it reaches this lowest point and further depreciates, vision will be professionally of no importance. Corresponding with these facts, the two curves of the economic visual acuities should not be marked as grades; the beginning and end of the curves should deviate, as we have shown, but these deviations are so little that we have divided them similarly to that of the scientific standard. The fine line (II) shows the course of economic vision for higher, and the broken (III) line for trades having lesser visual demands. As the drawing shows, both curves start together with the absciss-axis, and then when the climax of the demands is reached, they run parallel.

We have also evolved test types corresponding to those of Jäger for proximal vision and to Snellen's for distant vision (see Plates II and III). The ordinary Snellen test cards may be used in the same way by reducing the scientific standards to economic terms.

§13. *The Economic Limits of the Visual Field and their Estimation.*

The limits of peripheric vision are to be regarded from either a scientific or an economic standpoint, and as has been shown in discussing the visual acuity are quite different. Peripheric limitations or even greater defects of the field of vision, if only in one eye, and under certain circumstances, a moderate limitation of the visual fields of both eyes, will not impair their earning capacity. We would only regard limitation of the field of vision as entitled to an indemnification, if the limits for white in the binocular field are temporal 70°, superior 40°, inferior 60°; and in the monocular type, temporal 70°, nasal 45°, superior 40°, inferior 65°. This corresponds to those limitations which Haab (15, Table I., figure 1a) adopts as the narrowest ones admissible under normal conditions. The suggestion of Schroeter (37, p. 16) is very useful in estimating the amount of economic damage to the field of vision. Therefore, like Schroeter, we divide the binocular field into three zones of 30° each: the first from the outermost periphery to 60°, the second from 60° to 30°, and the third from 30° to the point of fixation (Plate IV., figure 1). It is evident that these three zones do not have the same value functionally; the inner one has the most, the outer the least, but nevertheless as it complicates the subject too much we do not give them a different value like Schroeter does. We are of the opinion that the functional differences of these zones can hardly render itself felt economically, for the outermost zone of the field of vision represents a much greater range of the retina than the central, and the intermediate one represents a greater range than the inner one. But what the outer zone lacks in functional ability compared with the two others, it

makes up by its greater extent, so that for practical use the extent of the different zones is compensated for by the relative difference in the functional ability; therefore we give each of these zones the same value. The entire binocular field of vision P, would be composed of three factors of equal value. According to this all defects of the field of vision could be given their numerical valuation, for instance, with the loss of one eye we would lose $\frac{1}{6}$ of the binocular field, with a homonymous hemianopsia $\frac{3}{6}$, etc. In paragraph 11 we have noted the reasons for introducing the visual field as a root value into the formula for the visual act.

§14. *The Economic Relations of the Ocular Musculature and their Estimation.*

The outer ocular muscles have their peculiar relations to the earning power. In view of the fact that the binocular act of vision in its earning relations may only be regarded as preserved if all the ocular muscles be unimpaired, the functional disturbance of one single ocular muscle is a bad one, because with the paralysis of one muscle diplopia appears and immediately suspends the binocular act, causing thereby complete exclusion of the affected eye. Therefore, if both eyes are functional and the act of vision was binocular, a paralysis of one ocular muscle should be regarded from an economic standpoint in the same light as the complete loss of one eye, and the diminution of the earning ability must be the same as the loss of one eye, even if it be only temporary. Less consideration should be claimed for the loss of the function of one ocular muscle if the act were previously monocular. In such a case the loss of one muscle is only an inconvenience or may be termed a small injury. We regard the action of the outer ocular musculature as a sum of different muscular actions, corresponding with the number of the outer muscles, which makes a sum of six individual functions. By omitting one muscle, the muscular action will appear in the formula for the act of vision as a fraction, $\frac{5}{6}$. The fact that the six outer muscles of the eye are not of the same relative value for the earning capacity has also to be considered. Quite different demands are made by certain vocations; for instance, in the case of miners, the rectus superior is particularly needed (Nieden 31), while in other trades it is but little used. In all factors demanding clear vision in the distance, as that of sailors, the rectus externus is more used than in those professions whose work is near the eye; in the latter the rectus internus is the most prominent muscle and for general use we think that the internal rectus should be given the most prominent place as regards the earning capacity. This varying value of the outer ocular muscles in the different professions makes the valuation somewhat difficult; for, if we gauge the muscles by the standard put for one certain vocation, we would make a

mistake. For instance, if we give the valuation to the rectus superior that is needed in the case of a miner, it would be over-valuation for most of the other professions and an under-valuation of the other muscles. It is, therefore, for ordinary purposes, necessary to regard the outer ocular muscles as of equal value and to give each $\frac{1}{6}$ of the total. But in special cases we can do justice to the demands of the different professions and when necessary value them higher, for instance, $\frac{2}{6}$ or $\frac{3}{6}$. We have deemed it necessary to introduce the muscular action as a root value in the full formula for the act of vision (§ 11, p. 30.)

In only exceptional cases could injuries of the intrinsic muscles (affecting the accommodation or the pupil) have any special influence upon the earning ability, because, by the use of suitable convex glasses, the derangement may be overcome.

CHAPTER VII.

§15. *The Meaning and Estimation of the Ability to Compete. (K of our formula for the earning ability.)*

As we have explained in Chapter IV. the ability to compete is one of the three factors composing the full earning ability. We have shown that this is the least valuable of the three and that it should be inserted into the formula with a smaller valuc than the other factors. We will makc a few remarks regarding the position this factor takes in the estimation of the injury to the ocular earning ability.

When an individual receives an accidental injury, especially that of vision, the damage to him is a double one. First, there is the impairment of his working ability from the results of the accident in that he cannot perform as good or as much work as formerly, and second his chances for obtaining work quickly and easily are less. This second factor is not so unessential as one might suppose. Practical experience shows that the one-eyed person not only has morc difficulty in finding employment, but that in some factories his visual disorder makes it difficult for him to retain his employment. Workmen with sound eyes are preferred by most employers of labor and from their standpoint, certainly not without reason. The injured person, therefore, has a right to claim not alone a compensation for the impairment of his capacity for work but also the difficulty which he encounters in making the most of this capacity. Therefore, in estimating the impairment of the earning ability, we have always and under all circumstances to consider the diminution of the ability to compete.

The ability to compete is a conception resulting from a combination of heterogenic elements of which a part lies in the individual himself and is affected by the condition of his health, his knowledge, etc., while another portion is beyond his control. It is this latter element the world values in judging the ability of the individual. Thc ability to compete in the labor market, the possibility of finding employment, is fixed, therefore, by the physical and mental ability of the individual as well as by the way others judge of it. If we apply this reasoning to the organ of vision, the ability to compete of each individual will depend firstly upon the ability of the visual organ and secondly upon the way others are judging its condition; an example should render this clear. Supposing some one has suffered an injury to one eye and seeks employment, his chances of obtaining the desired work will depend first, upon his visual powers and secondly, upon the way the employer judges

them. The employer will be willing to give or refuse work to this particular individual according to how he regards the injury of the eye as detrimental for the performance of his particular work. If we desire to state the ability as a numerical quantity, we must consider such conditions, which we think we can do by the following:

THE PART OF THE ABILITY TO COMPETE THAT EACH INDIVIDUAL SUPPLIES BY HIMSELF, in our case the ability of his organ of vision, we bring forward into the formula under normal conditions when we insert the expression for the normal act of vision, $C\sqrt{P}\sqrt[4]{M}$, but in the case of accidents the impaired value of the act of vision should be put in as the lowest value in the root. In Chap. IV, § 9, we have given the reasons for accepting the ability to compete as the lowest value and we have likewise shown that the ability to compete is of less value in the formula for the earning ability E than the other factors, *i. e.*, it has a smaller influence upon the value of E than the others. We have, therefore, adopted the ability to compete K as a root value. For, if K be reduced by an impairing of the act of vision, it becomes a proper fraction, for instance, $\frac{K}{z}$. Now the root of a proper fraction is always greater than the fraction itself; the value of K after the impairment if it is taken as a root value can not any more be $\frac{K}{z}$ but it must be greater, for instance, $\frac{2K}{z}$. By taking K as a root, its value, in the case of a visual impairment, is greater than it would have been if K without root would have been taken into the calculation. And as the amount of the earning ability is directly fixed by the amount of the ability to complete, K exercises less influence upon the earning ability than the other factors, as soon as we insert K as root in the formula for the earning ability. The full formula being: $\sqrt[x]{K} = \sqrt[x]{S_2\sqrt{P}\sqrt[4]{m}}$.

THE PART OF THE ABILITY TO COMPETE NOT DEPENDING UPON THE INDIVIDUAL, IN OUR CASE NOT UPON THE CONDITION OF THE EYES, BUT UPON THE JUDGMENT OF THE EMPLOYER. we render by the exponent of the root which we chose for K: taking a small exponent the value of $\frac{K}{z}$ will be enhanced to a less extent and if we take a large exponent to a higher extent. If we enhance the value of the ability to compete by taking a greater root exponent, as the earning ability increases as much as the ability to compete becomes greater, the earning ability will be greater according to the size of the root exponent. If we would indicate that the employer regards a certain ocular impairment as an important diminishment of the working capacity we would take a smaller exponent, but if we intend to show that an ocular impairment is of

less importanee to the employer, we would take a greater one. We, therefore, ehoose for all slight and moderate visual impairments a different root exponent than for the serious ones; therefore, for the slight impairments we give the ability to compete the root exponent 10, but if the impairment of central vision is serious, *i. e.*, in the case of professions with higher visual demands if it falls below 0.15 and in those with less demands below 0.05, and instead of the root exponent 10 we take the exponent 5 for these professions with greater visual demands and the exponent 7 for those with less. The same is to be done in the case of the complete loss of one eye or in the case of the loss of the eyeball. If we think that the aesthetic differences between simple blindness of the seientific standard without injury to the looks of the eye and the loss of the eyeball, or, for instanee, the formation of a bad looking eye, as leucoma or staphyloma are greater, we may give expression to our opinion by choosing a great root exponent for the ability to compete in the case of simple blindness without deformity. By leaving the selcetion of the root exponent to the judgment of the ealculator, suffieient room is given for the individual eoneeption of eaeh case; *thus our formula adapts itself to the peculiarities of the individual case and to the judgment of the physician, avoiding thereby a rigid form and doing justice to both parties.* Therefore, in forming a speeial estimation of the ability to compete we first fix the amount of the injury to the act of vision in eaeh ease, and upon this depends that part of the ability to eompete whieh the individual furnishes himself. As regards the seeond part, in eertain eases it will be found that while there is no or but little actual injury to the visual sense itself, yet eertain injuries of the eye disturb the relations of the individual to the employer.

Sueh a ease as the following is often experienced in practice: A man has his eornea burned by lime whieh leads to the formation of leueoma and diminishes the visual acuity of that eye to 0.25 of the normal, the other eye remaining well. Thus, although such an individual is not optieally impaired for his work beeause the normal eye allows the undisturbed following of his trade, the chances of his finding work have beeome less. A great many employers would hesitate to take into their serviee a man with a bad looking eye, who shows so plainly the effects of the injury or who, he knows, ean see normally only with one eye; in spite of the fact that in such a case an actual impairment has not taken plaee the ability to eompete is eertainly diminished. We are consequently in the peculiar position of estimating an ocular impairment of the ability to compete when there is no real defeet of working vision. Thus we think we ean meet these difficult eonditions in the best manner if we express the diminution of the ability to compete in all cases by the arithmetieal proportion of the visual acuity of both eyes. The ability to compete is in fact a quantity which is almost identieal with the act of vision but not dependent upon it as the maximum

of the visual acuity in both eyes. In our example we suppose that the vision of one eye remains normal while that of the other was diminished to 0.25, consequently the numerical expression for the ability to compete would be:

$$\sqrt[10]{\frac{1 + 0{,}25}{2}} \sqrt{P} \sqrt[4]{(m_1\ m_2\ m_3\ m_4\ m_5\ m_6)\ (m_1'\ m_2'\ m_3'\ m_4'\ m_5'\ m_6')}$$

The reasons for expressing the impairment of the ability to compete by the arithmetical proportion of the central acuities of both eyes are the following: Even if a diminishment of the binocular acuity of vision cannot be proven scientifically where one eye is alone affected, professionally the binocular vision has not the same value as formerly. If we unite the normal vision of the one eye and the impaired one of the other by the mathematical expression of the arithmetical proportion, the value of the normal acuity will be diminished by the size of the injury to the other eye; we then use this arithmetical proportion as the root value with the exponent 10 and thus provide that the normal vision is but slightly redueed by the impairment of the vision in the other eye. By this means the practical conditions may be satisfaetorily considered. If one of the other factors entering into the economic act of vision be impaired, for instance, the peripheric vision, while all the other factors as well as the central acuity remain untouched, the impairment of the factor in question should be used in such a manner that we first insert it into the expression for the normal act of vision as the tenth root in the calculation. For instance, from an accident only the field of vision has suffered and if it is only two-thirds of its original range while the central acuity and the muscles remain unchanged, we enter into the formula for the normal professional act of vision for the field of vision P the value two-thirds. The formula for the ability to compete would thus be:

$$\sqrt[10]{C \times \sqrt{\tfrac{2}{3}\,P} \sqrt[4]{(m_1\ m_2\ m_3\ m_4\ m_5\ m_6)\ (m_1'\ m_2'\ m_3'\ m_4'\ m_5'\ m_6')}}$$

If several of the factors be damaged at the same time, the amount of such damage has to be inserted into the formula as the xth root. For instance, the central acuity of vision in both eyes diminishes to 0.30 (scientific value), while the field of vision be limited to one-third, these values for the acuity and the field would have to be first entered into the formula of the working act as an arithmetical proportion, being changed correspondingly while the numerical value of the muscular action would remain the same, the formula then would be:

$$\sqrt[x]{\frac{0{,}30 + 0{,}30}{2}} \sqrt{\tfrac{1}{3}\,P} \sqrt[4]{(m_1\ m_2\ m_3\ m_4\ m_5\ m_6)\ (m_1'\ m_2'\ m_3'\ m_4'\ m_5'\ m_6')}$$

and if we enter this below the tenth root, the formula would be transposed into:

$$\sqrt[10]{\frac{0.30 + 0.30}{2}} \sqrt{\tfrac{1}{3}P} \sqrt[4]{(m_1\, m_2\, m_3\, m_4\, m_5\, m_6)\ (m_1'\, m_2'\, m_3'\, m_4'\, m_5'\, m_6')}$$

If one eye be entirely lost, the disorder of the visual act would be represented, in vocations with higher visual demands, the fifth root, and in such with less demands the seventh root. The same calculation may be done for serious disorders which have the same relations as the loss of one eye.

CHAPTER VIII.

THE METHOD OF CALCULATION WITH THE FORMULA OF MAGNUS.

§16. *What Does this Formula Mean?*

In Our Formula for the Ocular Earning Ability, $E = F\sqrt[x]{K}$ the visual act being F and $\sqrt[x]{K}$ the ability to compete, by resolving the act of vision F into its physiologic factors necessary for the earning ability, C is the maximal central visual acuity, P the visual field and M the muscular action (Chap. VI., § 11-14), we had acquired the expression: $F = C_{(max.)} \sqrt{P} \sqrt[x]{M}$ for the physiologic act while for the ability to compete $\sqrt[x]{K}$ we had (Chap. VI., § 11-14):

$$\sqrt[x]{K} = \sqrt[x]{\frac{C_1 + C_2}{2}} \sqrt{P} \sqrt[4]{M}.$$

The complete formula for the ocular earning ability being the following:

$$E = C_{(max.)} \sqrt{P} \sqrt[4]{M} \sqrt[x]{\frac{C_1 + C_2}{2}} \sqrt{P} \sqrt[4]{M}.$$

At the first glance it might seem that our formula has too much of the mathematical stamp and that its handling does not seem easy nor convenient, and it has been called "too complicated" (Groenouw 12). But this reproach only shows that those making it did not comprehend or understand its meaning. This formula is the numerical expression for the normal visual earning ability, and while this is a composite quantity its mathematical expression must, of course, be composite. This is especially true, for each of the factors entering into the normal visual earning ability may be impaired and must have an individual influence upon the calculation. If we try to simplify the complicated relations they could only be forced, and an arbitrary speculation substituted for its own composite character. The formulas of Zehender and Groenouw are certainly not real mathematical expressions for the ocular earning ability, but only mathematical results of arbitrary suppositions. By the construction of such seemingly simple formulas we depart entirely from the line of conduct nature itself follows and get into devious tracks of arbitrary hypotheses. Our duty is to give expression to the ocular earning ability in a mathematical

manner according to its nature, but in doing this we must not create a formula made easier to handle, but which is nothing but an arbitrary conception. Arithmetical simplicity could only be arrived at by the waiving of the natural relations. While an exact mathematical rendering of these may not be so very convenient, we may expect that results may be gained which correspond with the actual conditions. By doing so, such *reductio ad absurdum* cannot be found, as is the case with the simple hypothetic formulas of Zehender and Groenouw. The arithmetical results of introducing human beings with three seeing eyes, or nine eyes, or cyclopia, or arriving at the conclusion that one-eyedness is identical with the entire loss of the ocular earning ability, cannot be excused or made acceptable by the arithmetical simplicity of the formula.

§17. *Can Figuring with the Formula Be Made More Convenient?*

In our last paragraph we had to defend our formula from the reproach of being too complicated, but, under all circumstances, it is the truest mathematical expression of natural conditions and has to be made the starting point for every calculation. We may, however, try to make it more convenient, as it must be admitted that the separate figuring of the individual factors with the root values certainly offers difficulties to the inexperienced mathematician and, therefore, a way has to be found which, while retaining absolutely the formula, materially facilitates and simplifies the calculation. This we do as follows:

In plate V we delineate each of the factors of our formula in a curve in such a manner that the individual curves give the condition of this factor within its working range. For instance, in plate V, line I shows the geometric course of peripheric vision, if the scientific value of P as absciss and the economic value $\sqrt{P}$ are taken as ordinates; line II represents the geometric course of the muscular action, if the scientific value of M as abscissa and the economic or actual value $\sqrt[4]{M}$ are taken as ordinates. The three lines, III, IV and V, show in an analogous manner the ability to compete in its different values, using the 5th, 7th or 10th root. By the assistance of these curves we may ascertain, in a given case, the economic value of the impairment of every factor of our formula. We first ascertain the amount of impairment on the abscissa representing the scientific valuation, then we trace vertically the corresponding line from this point on the chart, and at the intersecting point where we meet the ordinate on the left of the curve, is the economic value of the damage. By this method, the very inconvenient handling of the root values and separate figuring of the single factors of the formulae may be avoided. Thus, with any great amount of mathematical calculation, we may estimate the economic value of each damage of the different factors shown in the tables.

In comparing the estimation found in this way, with that resulting from actual calculation, we will find a certain difference which might be even in unfavorable cases as much as 1, 5 or 2.0, but which will be generally much less. Such a difference can hardly be avoided, because the drawing of the curves and the mathematical calculation can not be exactly in congruity; but as in the fourth part of this book we give a tabular exposition of all values gained arithmetically, we are always enabled to compare these with those found in the curves. Exact reading of the curves leads to accuracy of the result. By this method, the handling of our formula is materially simplified, so that its use offers no difficulty whatever. In order to prove this, we will present some cases to show the reader its convenience.

§18. *Calculation with the Formula.*

To recapitulate our formula:

$$E = C\sqrt{P}\sqrt[4]{M}\sqrt[x]{\frac{C_1 + C_2}{2}\sqrt{P}\sqrt[4]{M}}$$

C being the maximal central visual acuity, $\sqrt{P}$ the visual field, and $\sqrt[4]{M}$ the action of the extrinsic muscles and $\sqrt[x]{\frac{C_1 + C_2}{2}\sqrt{P}\sqrt[4]{M}}$ is the ability to compete. The latter is composed (Chap. VII., § 15) of the arithmetical proportion of the central visual acuity of both eyes $\frac{C_1 + C_2}{2}$, the peripheric vision $\sqrt{P}$ and the muscular action $\sqrt[4]{M}$, with the provision that we make the root exponent higher or lower, as the case may be, of the value 5, 7 or 10. Let us now figure some examples by the aid of this formula:

Example 1. In a simple case, one eye having suffered a traumatic diminution of the visual acuity which has a value of ½ or 0.5, according to the scientific standard. This injured person follows a trade which has higher visual demands, for instance, is a skilled iron worker. In such a case the maximum C. remains unchanged, because this is the higher visual acuity of the sound eye which remains the same. C, is therefore = 1, $\sqrt{P}$ the visual field, and $\sqrt[4]{M}$ the muscular action, remain unchanged. These three factors represent each the value 1. In this case the unknown quantity is the ability to compete, $\sqrt[x]{\frac{C_1 + C_2}{2}\sqrt{P}\sqrt[4]{M}}$ $\frac{C_1 + C_2}{2}$ being the arithmetical proportion of the central visual acuity of both eyes C, the uninjured eye, remains = 1; C_2 the in-

jured eye, should be reduced according to our supposition to 0.5 of the scientific standard. Looking now on plate I on the abscissa for the scientific value 0.5 trace this line upwards until we meet the economic curve (II), and from the point where the line cuts the curve we go to the left and find there on the ordinate the economic value of the scientific estimation for the acuity of vision. As the plate shows, this is about 0.58. By inserting this value in the arithmetical proportion of the acuity for both eyes, into $\frac{C_1 + C_2}{2}$ we have $\frac{1 + 0.58}{2} = 0.79$. This we insert into the factor $\sqrt[x]{\frac{C_1 + C_2}{2}} \sqrt[4]{P} \sqrt[4]{M}$; we then have $\sqrt[x]{0.79} \sqrt[4]{P} \sqrt[4]{M}$ in which $\sqrt[4]{P}$ and $\sqrt[4]{M}$ are each $= 1$; the whole value is then $\sqrt[x]{0.79 \times 1 \times 1}$. As this is only a slight injury the ability to compete cannot be impaired very much, consequently we make the root exponent $x = 10$. This value $\sqrt[10]{0.79 \times 1 \times 1}$ we can find in plate V, curve V. We look simply on the abscissa for the value 0.79, trace the line from there upwards until we meet curve V, going from there to the left we find on the ordinate the value 0.972. If we insert this value into the formula we would find $E = 1 \times 1 \times 1 \times 0.972$, and as E, in our formula, has always been a fraction of 1, it must be multiplied by 100 if it would be represented as a percentage. We have then for E=97.20. If we compare this value 97.20 with the example I (given in the first edition, Magnus, p. 90), which was 97.69, we observe that the difference between the two values is very small.

Example II. As a second case we will take impairment of the visual acuity in both eyes, one having only scientific standard of 0.3, the other of 0.4. The injured person may have a vocation demanding higher visual powers. How would we here figure with our formula?

$$E = C_{max.} \sqrt[4]{P} \sqrt[4]{M} \sqrt[x]{\frac{C + C_2}{2}} \sqrt[4]{P} \sqrt[4]{M}$$

The factor C (maximum) *i. e.*, the highest value of binocular visual acuity or what is in this case the same thing, the visual acuity of the better eye. As the scientific value is equal to 0.4, on plate I we look on the abscissa for this value, go to the curve and find that it is professionally equal to 0.41. The professional valuation of the different values for the visual acuity may also be found on Table B, p. 39.)

The factor $\sqrt[4]{P}$ remains unchanged $= 1$.

The factor $\sqrt[4]{M}$ remains unchanged $= 1$.

The factor $\sqrt[x]{\frac{C+C_2}{2}} \times \sqrt{P} \times \sqrt[4]{M}$ which is the ability to compete will be changed only in the part $\frac{C+C_2}{2}$ because the field of vision and the ocular muscles are not impaired; both will, therefore, be $=1$. This part $\frac{C+C_2}{2}$ would resolve itself in the following manner as the scientific acuity in one eye has diminished to 0.4 and in the other to 0.3, as we find out by the curve, the scientific standard 0.4 corresponds with 0.41 and 0.3 with 0.25; $\frac{C+C_2}{2}$ is therefore equal to $\frac{0.41+0.25}{2}=\frac{0.66}{2}=0.33$. The entire factor of the ability to compete $\sqrt[x]{\frac{C+C_2}{2}} \times \sqrt{P}\sqrt[4]{M}$ would be, if we enter the values in place of each part: $\sqrt[x]{0.33 \times 1 \times 1}$, and the economic equivalent of this value we can find directly on plate V. We have only to decide if the eyes have been disfigured from leucomata of the cornea resulting from the injury and if from the æsthetic standpoint the ability to compete has suffered. If this be the case, we take for the root exponent 5 and look on plate V on the abscis for 0.33; from there we trace upwards till we meet curve III and read to the left on the ordinate the economic value 0.806. The ability to compete would, therefore, be equal to 0.806. If we now enter all the values we found into our formula we transpose it as follows:

$$E = C_{max.} \times \sqrt{P} \times \sqrt{M} \times \sqrt[5]{\frac{C+C_2}{2}} \times \sqrt{P} \times \sqrt[4]{M.}$$

$E = 0{,}41 \times 1 \times 1 \times 0.806 = 0.33046$ which in the form of a percentage equals 33.064 per cent. But, if we should take in the foregoing example a slighter impairment of the ability to compete and figure it, not with the exponent 5 but with the exponent 10, we would receive the result $E=37.331$ per cent. The earning ability in this case would be 4.285 per cent greater. These examples should be sufficient to explain our methods.

We now see that calculating with our formula is really simple. All we need is to insert the values of the individual factors into the formula as we find them on the plates. When this simple procedure is done, the formula has been reduced to an easy multiplication example. As we have said before, by reading the curves the values found are often a little different from those by full calculation; but as this difference is not great and may be avoided to a great extent by a careful reading, this fact deserves but little con-

sideration. Besides this, the values found by reading the diagrams may at any time be regulated by comparing them with the tabulated values compiled in part IV.

We believe that by construction of the curves, the calculation has been so simplified that in spite of the seemingly complicated composition of our formula, it can be done by even an inexperienced mathematician. Reservation must be made in cases where the injured person had possessed before the time of the accident only one eye or was weak sighted. In such cases special modifications of the calculation have to be made which will be explained in the following chapters.

PART SECOND.

Special Consideration of Various Ocular Injuries and Visual Defects.

CHAPTER IX.

§19. *The Relative Importance of Disturbances of the Visual Field.*

In estimating defects of the visual field we should remember that two-thirds of the binocular field belongs to and is controlled by both eyes (yellow area of Fig.1, plate IV.) Under certain circumstances these disorders have only monocular effects. For instance, in the case of nasal hemianopsia (Schroeter 38, p. 19 and our Plate IV, Fig. 3.) Such limited disorders are not considered detrimental to the earning ability because the field of vision does not suffer restriction of its normal limits.

An experienced calculator may easily ascertain the arithmetical values of the different defects of the visual field, but for completeness' sake we here develop these values for a series of disorders which may be inserted into the formula for the earning ability. The following explanations are considered only for the binocular field of vision:

1. Concentric peripheric contraction of slight extent with normal central visual acuity not extending to 70° (Chap. 7, § 13) is of no importance in this relation and thus may be omitted. If it exceeds 70° but does not go beyond 60°, the field of vision P is to be inserted as two-thirds, into the formula for the earning ability. The earning ability is then 80.012*; its impairment being 19.998.

2. Concentric peripheric contraction of a greater extent with normal central visual acuity materially exceeding 60°, reaching 30° causes two-thirds loss of the binocular field, the remainder of which should be considered as one-third in the formula for the earning ability; consequently the earning ability drops to 54.65 (55 per cent.); the impairment being 45.35 (45 per cent.) The same estimation is given for any limitations between 30° and 60°.

3. Concentric peripheric contraction of the highest degree with remaining normal central visual acuity always means, according to our supposition, an entire inability to earn (Ch. V, § 11). Schroeter (37, p. 21) takes for granted that in such cases an earning ability of 25 per cent. may still exist and that the impairment would only be 75 per cent., but according to our practical experience, we cannot share this view with Schroeter. A man who has only central vision left is, under all circumstances, entirely unable to work and should be allowed 100 per cent. indemnity for the loss of his earning ability. Practically such cases are not frequent, at least not as

*For simplicity's sake the calculation may be made with the whole numbers 80 per cent. and 20 per cent.

accidental injuries. The double-sided hemianopsias which are likewise very infrequent (Magnus 24) and of which there has only been reported one traumatic case (Schmidt-Rimpler 35, p. 181) are considered in the same category.

4. Concentric peripheric contraction of the field of vision in one eye causes diminishment of the entire field of one-sixth, as only the exterior portion (the red or blue area in Fig. 2) is monocular. The sound eye will equalize the disorder of the common portion of the field of vision caused in one-sided concentric contraction. Even very serious concentric contractions limited to one eye will impair the total value of the field of vision to but one-sixth; the earning ability in such cases is 90.458 (90 per cent.); the impairment 9.542 (10 per cent.)

5. Homonymous hemianopsia dextra vel sinistra causes loss of 1½ the binocular field of vision, the earning ability becoming, according to our estimation, 68.302 (70 per cent.); the impairment 31.698 (30 per cent.) We make no difference between right or left-sided hemianopsia, but for the purpose of indemnification give them the same value. Schroeter (37, p. 17-18) proposes to allow 45 per cent. for right-sided hemianopsia and 30 per cent. for left-sided, because, according to his idea, the right half of the field of vision is professionally of more importance than the left one. While it must be admitted that the loss of the right half of the field of vision is especially embarrassing in the beginning for certain occupations, for instance, reading and writing, and is more inconvenient than in case of the corresponding loss of the left half, we would not indemnify hemianopsia on the right side higher than the left, for it is always a question whether or not the above difficulties are more of a psychical character (Knies 16, p. 28) than due to the actual loss of vision: then again those men who are generally exposed to accidental injuries do but little reading or writing in their business; and then the person ultimately becomes accustomed to using the left sides of the visual fields. Besides this there are many occupations in which the loss of the left field would be as bad as that of the right and for left-handed persons the loss of the left side would certainly be more inconvenient than that of the right. We, therefore, do not advise a higher valuation of the right field of vision.

6. In the case of vertical homonymous hemianopsia the loss is equivalent to that of the horizontal forms: Schroeter (37, p. 20) complicates the matter again in that he makes a difference in the valuation of the upper and the lower half of the field.

7. The loss of both the temporal halves of the field of vision leaves two-thirds of the binocular field, but this is not any more a common field; the left half belongs to the right eye and the right half to the left (Plate IV, Fig. 2); but this condition does not seem to produce special disorders in actual practice. We enter the value of this field of vision as two-thirds P in the formula for the earn-

ing ability which results in the value 80.012 (80 per cent.); and for its impairment 19.988 (20 per cent.) Schroeter (37, p. 19) gives this value as 20 per cent., making our figures about the same.

8. By the absence of both nasal halves the common field suffers much restriction, as there are no more peripheral portions common to both eyes. The two temporal halves of the field of vision left, touch each other at the point of fixation (Plate IV, Fig. 3), the right half of the field (blue in Fig. 3) belongs only to the right eye, the left half (red in Fig. 3) only to the left. Because the field of vision has not suffered a restriction and there is no acuity from this condition, the earning ability is not curtailed.

9. Absence of the nasal half of the field of vision in one eye does not cause diminution of the entire field because both the nasal halves are in the common binocular field (yellow area, Plate IV, Fig. 1.) If one nasal half be lost, for instance, that of the left eye, it only causes a change in the form of the binocular field. The right half of the herctofore common field would now be monocular, belonging only to the right eye; the left half of the entire field would have the peripheric portion belonging to the left and a central one common to both eyes while the right half to the full extent of the field of vision belongs only to the right eye (Plate IV, Fig. 4). An impairment of the ability to earn could not be deduced from this condition because the extent of the total field of vision has not suffered restriction. Cases occurring under the headings of 8 and 9 could be used to prove that accidental injuries do not always cause impairment of the earning ability or allow of claims for indemnification. This is noted in the German Accident Insurance Law, Chap. I., § 3.

10. Loss of the temporal half of the field of vision of one eye from the point of fixation to the outer part, for instance, of the right eye (Plate IV, Fig. 5) affects only the range of the total field of vision supplied by the right eye (blue area, Fig. 1) According to our classification, the binocular or total field would be diminished by one-half of the exterior concentric zone (Fig. 1) which would be one-sixth of the total field. The field of vision left would represent five-sixths of the original amount, but the right half of the common field would now be only a monocular one belonging only to the left eye; the left half of the common field would be unchanged, the field would then take the form of Fig. 5, Plate IV. According to our calculation the ability to earn would be 90.458 (90 per cent.); the impairment thereof 9.542 (10 per cent.) Schroeter's estimation (38, p. 21) for the latter is 10.8.

11. Partial defects in the field of vision in only one eye are very seldom injurious to the working ability, if they affect only the common range of the total field (yellow area, Plate IV, Fig. 1), because the portion lost in the one field is compensated for by that of the other. But, if the particular defect reaches into the monocular part of the total field (into the red or yellow part of Fig 1),

a diminution and with it a disorder of the field of vision could be shown. In such cases we suggest an estimation according to the quota for the loss, for instance, if it comprises one-half the monocular part of the field, the earning ability would then be 90.458 (90 per cent.); the impairment thereof 9.542 (10 per cent.)

12. Partial defects of the binocular field should be valued according to their extent. The physician may settle how much is left after deducting the defect from the binocular field.

13. Total loss of the field of vision of one eye causes diminishment of the binocular field by only its peripheric part, one-sixth (the red and blue parts, Plate IV, Fig. 1.)

We condense these different results in a tabular form:

THE EARNING ABILITY AND THE IMPAIRMENT THEREOF IN THE DIFFERENT DISORDERS OF THE FIELD OF VISION WITH REMAINING NORMAL CENTRAL VISUAL ACUITY.

	VARIETY OF DEFECT.	Fractional value of the remaining field of vision.	PERCENTAGE.	
			Earning Ability.	Impairment.
1.	Partial defects in the field of one eye Concentric contraction of the field of one eye Absence of the temporal half Absence of the entire field of one eye	5/6	90,458	9,542
2.	Concentric contraction of both fields reaching to 60° Absence of the temporal half of both fields	2/3	80,012	19,988
3.	Homonymous hemianopsia dextra vel sinistra superior vel inferior	1/2	68,302	31,698
4.	Serious concentric contraction of both fields reaching to 30°	1/3	54,650	45,350
5.	Total concentric contraction of both fields reaching to 5°	0	0,000	100,0
6.	Absence of the nasal halves of both fields Absence of the nasal half of one field	1	100,00	0,00

The foregoing figures are made for both higher and lower visual demands where the central visual acuity remains normal. In cases of serious injury to the field of vision where the ability to

compete suffers it is necessary to figure for the higher demands where the 5th or 7th roots may be used. This is done in table VIIa, in the IVth part of this book.

§20. *Disorders of the Visual Fields Complicated by Injury to the Central Visual Acuity of Different Degrees in Either Eye.*

As in practice the peripheric visiou as well as the central acuity iu one or both eyes may be found injured, it is necessary to explain such relatious. In the following table the different disorders of the field of vision and the value of the remainders are given in the two left columns, while in the right column we find figures which serve for estimation of the earning ability, in all cases where there are disorders of the field of vision in connection with damage to the central acuity, differiug in either eye. We first settle what is the arithmetieal value of the remaining field of vision, for instanee, it might be five-sixths; then we find the value that the earning ability would have if the otherwise complicated disorder of the visual acuity alone existed. We theu read from tables V or VII of the fourth part without any trouble; if, for iustance, one eye has a visual acuity of 0.55 and the other 0.25, according to table V, the earning ability would be 61.078; if the injured person follows a profession demanding high vision. Now we multiply this value 61.078 with the number iu the table on page 63 next to the field of vision; as in our example the arithmetieal value of the field of vision would be five-sixths we would then have to multiply 61.078 with 0.90458; this would give us an earning ability of 55.250.

Let us take another example; in eoneentric contraetion of the field of vision reaehing to 30° in both eyes the arithmetieal value of the remaining field would be one-third; if one eye has central acuity of 0.40, the other of 0.20 and the demands in the profession of this particular individual are high, both the central aeuities of the vision would have an earning ability of 36.273; this value we would multiply with the number we find in the table next to the corresponding value of the field of visiou, *i. e.*, next to one-third —0.5465, from whieh the earning ability would result in 19.823 and its impairment 80.177.

If one eye be entirely lost while the other suffers impairment of its central acuity, the numerals given in the table ou page 63 do not hold good, we would have to use those on page 64; the ealculation is the same. We first ascertain (if for instanee one eye be totally blind and the other has only a visual aeuity of 0.4 and a field of vision of two-thirds, provided we have a profession with higher visual demands), the degree that the earning ability would have if the field of vision would not have taken part aud if the acuity of vision of both eyes had suffered to the above extent, which, according to table V, part IV, would be 24.166; this value we multiply with 0.57708 and get 13.946 as an expression for the degree of the earning ability. If the profession demands less vision we would multiply by 0.59238.

AUXILIARY DATA FOR THE ESTIMATION OF THE EARNING ABILITY IN DISORDERS OF THE FIELD OF VISION WHERE THE CENTRAL ACUITY OF BOTH EYES IS IMPAIRED DIFFERENTLY.

	Variety of Defect.	Fractional Value of the Field of Vision.	Percentage.
1.	Partial defects in one field. Concentric contraction (higher and lower degrees) in only one field. Absence of the temporal half of one field.	$\frac{5}{6}$	0.90458
2.	Small concentric contraction of both fields to 60°. Absence of the temporal half of both fields.	$\frac{2}{3}$	0.80012
3.	Homonymous hemianopsia dextra vel sinistra superior vel inferior.	$\frac{1}{2}$	0.68302
4.	Great concentric limitation of both fields reaching to 30°.	$\frac{1}{3}$	0.54650
5.	Total concentric limitation of both fields reaching to 5°.	0.00	0.000
6.	Absence of the nasal halves of both fields. Absence of the nasal half of one field.	1	As these disorders of the field of vision do not condition an impairment of the earning ability, only the disorder of the acuity of vision would have to be indemnified.

AUXILIARY DATA FOR THE ESTIMATION OF THE EARNING ABILITY IN LOSS OF ONE EYE COMPLICATED WITH INJURY TO THE VISUAL ACUITY AND VISUAL FIELD OF THE OTHER.

These four numerals are given by the following operation; whether the peripheric vision P is limited or not, we always have for the earning ability:

$$E = C\sqrt{P}\sqrt[4]{M}\sqrt[10]{\frac{C_1+C_2}{2}\sqrt{P}\sqrt[4]{M}} = C\sqrt{P}\sqrt[4]{M}\sqrt[10]{\frac{C_1+C_2}{2}\sqrt[4]{M}\sqrt[20]{P}}$$

$$= C\sqrt[4]{M}\sqrt{\frac{C_1+C_2}{2}\sqrt[4]{M}\sqrt{P}\sqrt[20]{P}}$$

The quantity $C\sqrt[4]{M}\sqrt[10]{\frac{C_1+C_2}{2}\sqrt[4]{M}}$, in which the muscular action M has to be regarded as abnormal, for a case in which one eye is lost, is taken directly from table V. or table VI.; to find E it must, therefore, be multiplied as follows:

P = 5/6	multiplied	with	$\sqrt{5/6}\sqrt[20]{5/6} = 0.90458.$
P = 2/3	"	"	$\sqrt{2/3}\sqrt[20]{2/3} = 0.80012.$
P = 1/2	"	"	$\sqrt{1/2}\sqrt[20]{1/2} = 0.68302.$
P = 1/4	"	"	$\sqrt{1/4}\sqrt[20]{1/4} = 0.54650.$

Where we have to figure the earning ability in the case of the loss of one eye, we have to multiply thus:

For Group I.	For Group II.
$P=3/5$ with $\sqrt{3/5}\sqrt[10]{3/5}=0.73602$	$P=3/5$ with $\sqrt{3/5}\sqrt[14]{3/5}=0.74685$
$P=8/15$ " $\sqrt{8/15}\sqrt[10]{8/15}=0.65580$	$P=8/15$ " $\sqrt{8/15}\sqrt[14]{8/15}=0.69832$
$P=2/5$ " $\sqrt{2/5}\sqrt[10]{2/5}=0.57708$	$P=2/5$ " $\sqrt{2/5}\sqrt[14]{2/5}=0.59238$

Regarding these fractions see Chap. XI., § 23.

CHAPTER X.

THE IMPAIRMENT OF THE EARNING ABILITY FROM INJURIES TO THE EXTRA-OCULAR MUSCLES.

§21. *General Remarks Regarding the Importance of Injuries to the Extra-Ocular Muscles.*

The ocular muscles have a peculiar position, for the binocular act can only exist so long as all the extrinsic muscles of both eyes are functionally undisturbed; as soon as one becomes paralytic, with the beginning of diplopia, monocular vision ends and for professional purposes only one eye is at the patient's disposal. For the person with two normal eyes, a paralysis of one muscle is practically identical, for professional purposes, to the loss of the eye and must be so considered in determining an impairment of the earning ability. If the injured person have only one eye, the conditions are quite different; for such a case a paralysis of one external muscle means a perceptible, but in a visual sense, a relatively insignificant impairment. For such a case the professional act of vision is not annulled, but is more or less disturbed. For exhibiting this peculiar relation of the ocular muscles, we considered in the formula for the professional *binocular* act of vision, the extrinsic ocular muscles as the factors of a product, to meet this demand; with the paralysis of only one muscle the binocular professional act entirely disappears and is changed into the monocular form because the product becomes 0 if only one factor becomes 0. In the formula for the *monocular* act of vision we express the arithmetical value of the extrinsic ocular muscles as the sum of 6 numerals, corresponding with the number of the ocular muscles. If one of these be lost, the sum only loses this numeral. In the monocular act of vision, as well as in the binocular, we introduced the numerical expression for the extrinsic ocular muscles as the 4th root, to be able to give expression to the different values of the ocular and muscular functions (Chap. VI., § 11). The other visual functions have a different value than the muscular movements, which may be considered only auxiliary functions of the visual act; professionally and arithmetically this fact cannot be neglected and so the ocular muscles have a root value in our formula. The formula for the binocular and monocular professional acts of vision have been made as follows (Chap. VI., § 14):

$$\text{Binocular Vision} = S_2 = C \sqrt{\ } P \sqrt[4]{\ } (m_1\, m_2\, m_3\, m_4\, m_5\, m_6)\ (m_1'\, m_2'\, m_3'\, m_4'\, m_5'\, m_6')$$

$$\text{Monocular Vision} = S_1 = C \sqrt{\ } \tfrac{5}{6}\ P \sqrt[4]{\ } \tfrac{2}{3}\ m_1 + m_2 + m_3 + m_4 + m_5 + m_6$$

§22. *The Estimation in Paralysis of Muscles Uncomplicated by Other Visual Disorders.*

In the foregoing paragraph we again developed the formulas for binocular and monocular vision. We will now try to figure the extent of the earning ability in disorders of the extrinsic muscles of originally normal eyes. As shown already, the earning ability is composed of the two factors of the act of vision and the ability to compete; the formula of the visual act is shown in the foregoing. In order to figure the value of the earning ability we will now have to state the formula for the ability to compete, which is the xth root of the visual act (Chap. IV., § 9; Chap. VII., § 15); in every ocular injury considered aside from the central acuity, the latter has the greatest influence upon the visual act and is placed with the arithmetical proportion of its two values into the formula for the ability to compete. If the injury be slight we choose the root exponent 10; when serious the exponent 5 or 7. In the case of the loss of one eye, we proposed to take 5 or 7 as the root exponent. As the binocular process is annulled for economic purposes, the individual has to be regarded as blind in one eye; but in fact there is really a difference between an actual one-eyed person and one who has to suddenly rely upon the monocular act of vision on account of paralysis of the muscles, because there is not only a chance of having the paralysis cured but later there may be some use of the eye which has been excluded from the binocular act for peripheral vision, as soon as the patient has learned to suppress double images. In cases of paralysis of the extrinsic ocular muscles we would insert into the calculation the ability to compete with the root exponent of 10 which we have chosen for ocular injuries of a slight or moderate degree. The formula for the ability to compete in the monocular act would thus be:

$$\sqrt[10]{\frac{1\,C+0}{2}}\sqrt{\tfrac{5}{6}\,P}\sqrt[4]{\tfrac{2}{3}\,(m_1+m_2+m_3+m_4+m_5+m_6)}$$

and the formula for the earning ability in the monocular act would be:

$$E = 1\,C\sqrt{\tfrac{5}{6}\,P}\sqrt[4]{\tfrac{2}{3}\,(m+m+....)}$$

$$\sqrt[10]{\frac{1\,C+0}{2}}\sqrt{\tfrac{5}{6}\,P}\sqrt[4]{\tfrac{2}{3}\,(m_1+m_2+m_3+m_4+m_5+m_6)}$$

After having developed in the foregoing formula the expression for the earning ability for a one-eyed person, we may figure by

concrete examples the impairment of the earning ability in case of disorders of the muscles.

Supposing somebody suffers by an accident a paralysis of the rectus externus of one eye; the binocular act of vision would be immediately excluded, because if the individual wishes to work at all he must cover the eye and therefore exclude it from the act of vision. The ability to earn which is left should be expressed by the above formula and this may be figured by using the curves in plate IV.; by inserting the different values the formula would be thus:

$$E = 1 \times 0.913 \times 0.904 \times \sqrt[10]{0.5 \times 0.913 \times 0.904} = 0.8254 \times \sqrt[10]{0.4127}$$

$= 0.8254 \times 0.915 = 0.755241$, or in percentage E equals 75.524, the impairment of the earning ability would be 24.476 per cent.

Suppose the external recti become paralyzed, then binocular vision is abolished and here the calculation of the amount of damage to the working vision would have to be started from the monocular standard. In figuring the professional loss we would consider that the value of the muscular action (as stated in the formula for the monocular act as $\frac{2}{3}\ m_1 + m_2 + m_3 + m_4 + m_5 + m_6$), would be diminished. Because the muscular action of the one eye used for seeing, if the rectus externus be impaired, would be represented by 5 and not by the full action of 6; it would therefore be:

$$\frac{2}{3}\ (m_1 + m_2 + m_3 + m_4 + m_5)$$

or more simply, two-thirds of five-sixths M. Entering this value into the formula for the monocular act of vision it would be:

$$E = 1\,C \sqrt{\tfrac{5}{6}\ P} \sqrt[4]{\tfrac{2}{3}\ \tfrac{5}{6}\ M} \sqrt[10]{1\,C + \frac{0}{2}} \sqrt{\tfrac{5}{6}\ P} \sqrt[4]{\tfrac{2}{3}\ \tfrac{5}{6}\ M}.$$

Transposing this by the assistance of the curves in plate V., the algebraic formula would be numerically expressed by the following:

$$E = 1.093 \times 0.863 \sqrt[10]{0.5 \times 0.913 \times 0.863} = 0.78792 \sqrt[10]{0.39396}$$

$= 0.7879 \times 0.911 = 0.717795$ or E = 71.78 per cent.

If in a case having the same acuity of vision more muscles be paralized in one eye than in the other, this eye should be regarded as excluded from the binocular act and the calculation may be made with the better. If one eye have a lower degree of vision, both having paralysis of the exterior muscles, that eye which has the better acuity should be regarded as the one which may be used in the profession, though its ocular muscles were more completely damaged. In the following table the earning ability and impairment thereof are given for different cases of paralysis, it being considered therein that the eye used for the profession has a working acuity of at least 0.75 for those vocations demanding higher vision and at least 0.50 for those with lower demands.

EARNING ABILITY AND IMPAIRMENT THEREOF IN UNCOMPLICATED DISORDERS OF THE EXTRINSIC OCULAR MUSCLES.

VARIETY OF DEFECT.	Arithmetical value of the muscles left.	Acuity of vision of the eye used in the profession.	Earning ability.	Impairment of the earning ability.
Paralysis of the extrinsic muscle of only one eye,	1	1—0.75 OR 1—0.50	75.496	24.504
Paralysis of the extrinsic muscles of both eyes; of the one eye used for working only one muscle is paralyzed,	5/6	1—0.75 OR 1—0.50	71.805	28.195
Paralysis of the extrinsic muscles of both eyes; of the one eye used for working two muscles are paralyzed,	4/6	1—0.75 OR 1—0.50	67.530	32.470
Paralysis of the extrinsic muscles of both eyes; of the one eye used for working three muscles are paralyzed,	3/6	1—0.75 OR 1—0.50	62.395	37.605
Paralysis of the extrinsic muscles of both eyes; of the one eye used for working four muscles are paralyzed,	2/6	1—0.75 OR 1—0.50	55.811	44.189
Paralysis of the extrinsic muscles of both eyes; of the one eye used for working five muscles are paralyzed,	1/6	1—0.75 OR 1—0.50	46.125	53.875
Paralysis of all extrinsic muscles of the eye used for working,	0	1—0.75 OR 1—0.50	0.00	100.00

§23. *Epicritic Remarks Concerning the Foregoing Results.*

It may perhaps at first sight be deemed remarkable that we find such a great difference between the earning ability in the case where 5 extrinsic muscles are paralyzed and the valuation of complete paralysis, for we have put down for the first instance an impairment of 53.875 while we state the latter as 100 per cent. The latter figure is certainly correct, for it is impossible for an artisan, even though he have normal acuity of vision, who suffers paralysis of all the extrinsic muscles which move the eyeball to be able to earn. The consensus of authorities gives the same opinion (Chap. VI., § 11). In specific cases, where only one muscle remains functionable, for instance, the rectus superior, a greater impairment of the working capacity might be found, for this muscle has but little influence upon the average vocation. If the rectus internus remains, the working capacity would be greater, for this is used much more often. Therefore, we might give each of the extrinsic muscles a different valuation (Chap. VI., § 13) in considering the specific demands of the vocations in which the injured person has previously labored, or we may get around this point by giving a higher valuation in such cases to the ability to compete; thus figuring not with the 10th but with a 5th or 6th root (table XIIIa, part IV).

By such a method we are enabled to simplify our mathematical calculations in specific cases, even though we treat all the ocular muscles equally. Thus by choosing the root exponents arbitrarily, the physician is allowed to express the individuality of each case. General calculations applicable for the individual values of each muscle cannot be given without doing violence to the peculiarity of the particular profession. Thus we hold it for the best to give each of the extrinsic muscles the same valuation, that is, one-sixth of the total value. We regard these figures as generally applicable as the lowest standard of the earning ability or the impairment thereof, leaving it to the calculator to change them eventually according to specific demands of the particular case. That paralysis of the levator palpebrae superior might suspend the use of the affected eye is self-evident and such a case should be considered professionally as one of monocular vision.

CHAPTER XI.

§24. *What Action is Necessary if the Injured Person Has Previously Only Had the Use of One Eye?*

The scientific and economic conception of monocularism is not the same. While, from a scientific standpoint, a person is to be regarded as one-eyed whose eyeball has been removed or who is otherwise hopelessly blind, the meaning of one-eyedness (monocularism) developed for professional life, has a much wider range. For economic purposes a man must be regarded as possessing only monocular vision who has but the one useful for the earning of his living, if the other has insufficient vision for this purpose. The condition of the poor eye and the degree of its visual acuity is immaterial in this consideration. If it is not a useful eye, that person may be considered to have but monocular vision for the purpose of earning his living, for he could not follow his trade if he lost the more normal eye, and would be in the same position as a man who had originally one blind eye or none at all. Although there is an optical and scientific difference, the economic consequence would be the same; both would be unable to work, although the weak and professionally insufficient eye in the one case, not being entirely blind, is of inestimable value to him; but this would have nothing to do in judging his ability to earn; he would be professionally incompetent if the uninjured eye is unequal to the demands of the trade. Therefore, for our purpose, we would regard many individuals as possessing but monocular vision who, according to the scientific standard, can see more or less with both eyes. Those who squint and suppress the image of one eye, those who have sufficient refractive error, which cannot be corrected or which lowers the acuity of vision to 0.15 or 0.05 (according to the visual requirements of the trade), those who have congenital monocular amblyopia, etc., belong to this class.

In the case of an individual whose previous condition would be professionally regarded as that of monocularism, who suffers an injury to his more normal eye, how would we estimate the earning ability? In the calculation of such a case the previous condition has to be considered and there is here a material greater impairment to the earning power than in the case of a person with two normal eyes. In the case of an ocular accident happening to a workman, we must not only consider his own peculiar ocular conditions but the side of the insurance company, employer or defendant from whom he may be seeking indemnification for his injury, so that we must be sure that the second parties are not burdened with the blame for an impairment which the laborer had before the accident. We solve this difficult problem with a just and

fair consideration of the claims of both parties, when we start with the supposition that with those workmen who originally possess only the working use of one eye, the condition should be regarded as normal, and therefore, for them the monocular act of vision is the normal one and equal in value to the binocular act of the person with two normal eyes. Thus out of fairness to the employer and the Insurance Company and the workman himself, we would not arithmetically consider the scientific standard of binocular vision in the case of a workman who has entered into his employment with only one working eye and who has suffered an injury to it. We calculate his claims in the same manner in which we figure the ability to compete (Chap. IV., § 9; Chap. VII., § 15), which is equal to the visual act and acuities of vision of both eyes in an arithmetical proportion thus:

$$\sqrt[x]{\frac{C_1 + C_2}{2}} \sqrt{P} \sqrt[4]{M}.$$

As in estimating the ability to compete of a person possessing monocular vision who has suffered injury to it through an accident, we put the visual acuity of one eye with its full value C under the $\sqrt{\ }$; thus the formula for the ability to compete of the one-eyed person would be:

$$\sqrt[x]{C} \sqrt{P} \sqrt[4]{M}.$$

This formula leads to the same results as that which we get for injuries to the visual acuity in binocular vision; as by this method, a man who has originally one eye would be impaired through an accident to his working eye to the same extent that occurs in a binocular case. When an employer hires an individual who is originally in possession of but one eye or who has practically only monocular vision, he does this under the supposition that this defect does not hinder him in his work and regards this condition as the normal for this particular individual. If this be the case, the ability to compete of such a man may be deemed normal and in estimating his earning ability we would take his ability to compete as the 10th root of the normal binocular vision of the man with two eyes. But regarding the chances of obtaining work we would repeat that there is a difference even in cases of monocular vision; for instance, if a person has in one eye an irregular astigmatism which diminishes the acuity below the working standard so that he cannot use this eye in a profession with higher ocular demands, for economic purposes he would professionally be deemed one-eyed, but he would be able to find work much easier than another laborer who has a bad-looking blind eye, for instance corneal staphyloma, through blenorrhœa, etc. Therefore, we would make an arithmetical difference between such cases, taking as the

exponent of the root for the ability to compete the number 10, where there is a good-looking eye and one not entirely blind; but in the case of a person with a bad-looking blind eye, for the higher ocular demands, we would take the exponent 5, and for lower ones 7; which are the same values that we took in the case of a workman who had originally two normal eyes. We give the following example: Supposing the vision of the sound eye in the case of a one-eyed workman be reduced to 0.65 (scientific standard) our formula would be the following:

$$E = C\sqrt{P}\sqrt[4]{(m_1 + m_2 + m_3 + m_4 + m_5 + m_6)}$$
$$\sqrt[x]{C\sqrt{P}\sqrt[4]{(m_1 + m_2 + m_3 + m_4 + m_5 + m_6)}}$$

As in this case the visual field and the ocular muscles are not impaired, and therefore 1, the reduced formula would be:

$$E = C\sqrt{1}\sqrt[4]{1}\sqrt[x]{C\sqrt{1}\sqrt[4]{1}}$$

Substituting the professional valuation of the scientific standard for 0.65 from our curves on plate I equals 0.833, and entering it now into the formula which would be:

$$E = 0.833 \times 1 \times 1\sqrt[x]{0.833 \times 1 \times 1}$$

the value $\sqrt[x]{0.833}$ will be found in the curves of plate V.; if for instance, we take the root exponent $x = 10$, then $\sqrt[10]{0.833} = 0.982$, which leaves the formula thus: $E = 0.833 \times 0.982 = 0.818006$ or E=81.801 per cent.

In the case of injury to the visual field in an originally one-eyed person we would figure according to the following: the field of vision of a one-eyed person, as we have seen in Chap. VI., plate IV., Fig. 1, is narrower by one-sixth than the field of vision of a normal person. If the right or left eye is gone, either the right or the left temporal segment of the common field of vision blue or red in Fig. 1, plate IV.) would be missing. Thus according to our arrangement, the monocular field contains 5 parts of the binocular one, which are ½ of zone I, ⅔ of zone II and ⅔ of zone III. Thus if we desire to make an arithmetical calculation of the limitation to the monocular field of vision, we should start with this five-part arrangement and express the impairments by fifths. The different estimates of damage to visual field would thus have the following values:

Loss of the temporal half there is retained..... $\frac{2}{5}$
Loss of the nasal half there is retained..... $\frac{3}{5}$
If the concentric contraction reaches 30° the value remaining is ..... $\frac{2}{5}$

If the limitation on the nasal side is more than 45°, on the temporal side 70°, below 65°, above 40°, the value of the remaining field of vision is $\frac{8}{15}$.*

In calculating the amount of damage to economic vision from injuries to the monocular field, we insert in our formula for the earning ability of the monocular act of vision for the value P the valuation of the remaining field of visison. Our formula being:

$$E = C \sqrt{P} \sqrt[4]{(m_1 + m_2 + m_3 + m_4 + m_5 + m_6)}$$

$$\sqrt[x]{C \sqrt{P} \sqrt[4]{(m_1 + m_2 + m_3 + m_4 + m_5 + m_6)}}$$

Supposing the remaining portion of the field of vision equals two-fifths, the central visual acuity C and the valuation of the ocular muscles $\sqrt[4]{(m_1 + m_2 + m_3 + m_4 + m_5 + m_6)}$ remain unimpaired, being equal to 1, the reduced formula would be:

$$E = 1 \sqrt{\frac{2}{5}} \sqrt[4]{1} \sqrt[x]{1 \sqrt{\frac{2}{5}} \sqrt[4]{1}}$$

and as each $1 = 1$, the resultant formula would be:

$$E = 1 \sqrt{\frac{2}{5}} \; 1 \sqrt[x]{1 \sqrt{\frac{2}{5}} \; 1}$$

and which can be readily figured, or, if preferable, the valuation can be easily found with the assistance of the curves in plate V.

*The value $\frac{8}{15}$ above figured is thus explained: The limitation reaching temporally to 60° from the fixation point leaves $\frac{4}{5}$ of the field of vision, of which a part is lost when the limitation above is over 40°, below over 65° and on the nasal side over 45°, which we estimate as a $\frac{1}{3}$ loss of the remaining $\frac{4}{5}$ of the field; therefore, there remains $\frac{2}{3}$ of $\frac{4}{5} = \frac{8}{15}$.

CHAPTER XII.

ESTIMATION OF ACCIDENTAL INJURIES IN THOSE CASES IN WHICH ONE OR BOTH EYES DID NOT POSSESS, BEFORE THE ACCIDENT, SUFFICIENT NORMAL CENTRAL VISUAL ACUITY.

§25. *The Meaning of Weak Vision from an Economic Standpoint.*

There are many cases to which trauma occurs in which the eyes had some previous disorder or disease affecting the visual acuity, field of vision or the ocular muscles. It is more especially defective visual acuity that is here considered. A recent article by Walther (47) who reported upon the examination of the eyes of 2,672 active workmen (printers, metal workers, wood workers, glass and porcelain workers, woolen workers, electrical and gas workers) found that exclusive of refraction defects that could be corrected by lenses, 611 were more or less amblyopic. Of these 347 (63 per cent.) had congenital defects; 224 (36 per cent.) acquired defects: 95 being of doubtful origin. In 15 per cent. the poor sight had been caused by the work. Every practitioner knows how common are opacities of the cornea and other disorders of the ocular media which affect the visual acuity in those classes of people that furnish laborers and artisans. Considering further how many cases of strabismus, anisometropia, high grades of astigmatism and refractional anomalies which are accompanied by weakness of vision of one or both eyes, we will have to admit that many cases of ocular accidents have previously had weak sight and whose acuity of vision did not reach the economic limit, i. e., 0.75 or 0.50. If the physician, who is called to estimate the amount of visual damage, finds indisputable proof that there was weakness of vision before the accident, what should be his action in fixing the ability to earn? If after an accident to both eyes, he finds only a visual acuity of 0.40, he must decide regarding the previous condition of the eyes, for the weakness of vision after the accident may not be solely the result of the trauma, but due in part or whole to causes not connected with it. In such cases particular care must be observed in the arithmetical estimation of the resultant damage to vision; we are certainly not justified in drawing conclusions from uncertain suppositions about the earning ability before the accident. If we cannot get reliable information concerning the injured person of the results of previous examinations, our estimation would depend entirely upon the impression gained by the present condition of the eye. There are many individuals who combine an astonishing

amount of working and earning ability with exceptionally low visual acuity, as has been shown by Groenouw's examples. Therefore, we cannot give each individual, whom we suppose had a weakness of vision before the accident, an earning ability in proportion to the hypothetic degree of this weakness. The possibility or even probability is, that this weak sighted individual possessed a greater ability to earn than might be supposed according to objective results. Therefore, the physician should only consider reliable communications, such as an exact functional examination of the eyes, regarding the previous extent of the weakness of vision in the particular case. If he has no such data, each person suffering from an ocular accident should be regarded as formerly normal; for even if there is a conviction that there was formerly a weakness of vision, justice demands that an arithmetical valuation of the former condition could be secured only by a previous functional examination. But this general rule, of course, may be laid aside in those cases in which there are decided opacities of the ocular media, congenital defects, which, through their appearance, have evidently existed for a long time previous to the accident, etc.; the physician may positively know that such have precluded the possibility of previously existing good working conditions. As this German Accident Insurance law was passed with benevolent intentions of protecting the workingman, we divine that his interest should be placed foremost. If we do this, we should stick to the principle that a former weakness of vision should diminish the claims for indemnification of injured workingmen only in such cases where the extent of the weakness of vision before the accident has been fixed by a reliable functional examination. Certainly the Utopian idea of examination of the eyes and other organs of all workingmen before taking employment and at stated intervals thereafter, according to Zehender and others of our colleagues, would fix this matter, but such is impractical except for the railroad, army and other kindred services. A systematic examination could only be made by a qualified oculist, and it would be impossible, as many factories are in small towns that cannot support an oculist. Likewise the financial question renders it impractical, for neither the workingman nor the employer is at present willing to stand the expense, and surely the physician should not be required to give his time for nothing, especially considering that he would have to write a certificate and accept responsibility in every single case. Then again, one examination is not sufficient; each one should be re-examined from time to time, as has been done in the railroads. For the latter service, re-examinations are conducted every few years or upon applications for promotion. Such examinations are certainly demanded for this class of workmen, for upon their eye-sight and physical condition depends the lives of many others.

§26. *Estimation of the Earning Ability in Case Weakness of Vision Existed Before the Accident, Which Can Be Numerically Fixed Through a Former Functional Examination.*†

If a workman suffers impairment of his visual acuity by an accident and data exists of his former condition, this weakness should be taken into account in estimating the damages caused by the accident. If in such a case we had based our estimation upon the ocular conditions of the formerly normal-sighted person, the injury would then receive an indemnification which is too high; being recompensed for the loss of a something which he never possessed. To prove the correctness of this assertion, let us look at the following case:

A workingman coming under Group I who had in one eye formerly only 0.60 visual acuity, suffers an injury which diminishes this to 0.40, should he be indemnified the same as if he had formerly normal visual acuity? This man has still $\frac{0.40}{0.60} = \frac{2}{3}$ of his former vision, but if his former weakness would not be considered, he would be indemnified as if his resultant vision was only $\frac{0.40}{0.73} = \frac{8}{15}$

Thus allowances for the former visual acuity in cases will have to be made where it is known. Thus, in the estimation of such a case, we would not enter the quantity 0.40 into the formula, for this would result in too great indemnification, but another X, which bears the same ratio to the unity of the particular group (here higher visual demands, 0.75) as the remaining acuity of vision after the accident (0.40) to the former (0.60) as in the following proportion:

$$x : 0.75 = 0.40 : 0.60$$

$$x = \frac{0.75 \times 0.40}{0.60} = 0.50$$

As in those cases the use of such an auxiliary quantity is necessary, we will introduce for it a special expression:

Definition: If n is the normal acuity of vision (for workingmen with higher visual demands $n = 0.75$; for workingmen with lower demands $n = 0.50$); n_1 the original acuity of vision of the weak-sighted and c_1 the acuity of vision after the accident.*

We would understand under "modified visual acuity," an acuity c_1' which suffices for the proportion $c_1' : n = c_1 : n_1$ from which we get the equation: $c_1' = n \frac{c_1}{n_1}$.

†In forensic practice the following examples will be seldom found. Considerable space is given for such cases here to show that our rules are universal and adapted to the most complicated as well as the simpler cases.

*In using the reading tables, the remaining visual acuity after an injury would be the scientific standard and would have to be changed into the professional one.

This expression would be used for the original visual value under the following circumstances: if a person begins a trade or vocation with a weaker normal visual acuity than n which we would denominate n_1, and then has this eye injured so that ultimately there is a visual acuity of c_1, the estimation of his indemnification should be based upon the modified visual acuity c_1' and not the original acuity c_1. If the person be weak-sighted in both eyes, n_2 and c_2 mark the values for the second eye, corresponding to the quantities n_1 and c_1; thus the modified visual acuity c_2' must be introduced, as the act of vision is, in this case, dependent upon two modified acuities c_1' and c_2'. One of these quantities would generally be greater, if both be equal, it is immaterial which we choose; one should be marked by $c'_{max.}$ The formula for the visual act would thus be:

$$S_2 = c'_{max.} \sqrt{P} \sqrt[4]{M.}$$

As at present we only deal with the factor of visual acuity, considering in our examples that the peripheric vision and muscular action are normal, thus estimating their value as 1 in the equation:

$$S_2 = c'_{max.} \times 1 \times 1.$$

We have now found a value for the visual act S and will have to consider the second factor, the ability to compete K, for the estimation of the ocular earning ability E. This quantity K we have identified for our purposes with the act of vision itself but with a difference, whereas we made this factor dependent only upon the miximum of the central acuities of both eyes, we introduced into the other in its stead the arithmetical proportion of the central visual acuities. And as in our case we must regard the modified acuities c_1' and c_2' as ideally existing, it would seem at first glance as if we had to figure with these and to insert for K the value $K = \frac{c_1' + c_2'}{2}$, where we again disregard the quantities $\sqrt{P}$ and $\sqrt[4]{M.}$ Such a supposition would be in opposition to statements previously made. Indeed, the ability to compete is a quantity which depends more upon others than upon the individual himself, and while we had to say in figuring the visual act: The visual acuities c_1 and c_2 have for the individual the value c_1' and c_2'; we cannot definitely assert a value for this quantity as it is dependent, to a small degree, upon the individual himself. If in the estimation of K we would take as auxiliaries, the modified visual acuities c_1' and c_2' we would express therewith the idea that the acuities of vision c_1 and c_2 have in other cases these modified values and this supposition is not supported by facts. This simple reflection forces us to accept K in the

form $K = \frac{c_1 + c_2}{2}$ and inserting this and the value of the former vision into the general formula for the earning ability $E = S \sqrt[x]{K}$, the result would be:

$$E = c'_{max.} \sqrt[x]{\frac{c_1 + c_2}{2}}$$

It would seem almost as if a great many tables were desirable for figuring the above formula, because $c'_{max.}$ and $\frac{c_1 + c_2}{2}$ may have many different values and allow of numerous combinations, but it is possible to make use of the above expression for E without going into such detail. We will use the former expressions and mark for $c_{max.}$ the greater of the two visual acuities c_1 and c_2; then if, for instance, $n = 0.75$ or 0.50, we estimate from our two main tables V. or VI., part IV., as an auxiliary quantity an earning ability E which is given in the proportion:

$$E = c_{max.} \sqrt[x]{\frac{c_1 + c_2}{2}}$$

out of this we get the value of the 10th root

$$\sqrt[x]{\frac{c_1 + c_2}{2}} = \frac{E'}{c'_{max.}}$$

and by inserting this value into the above formula for E we get

$$E = c'_{max.} \sqrt[x]{\frac{c_1 + c_2}{2}}$$

which reduced to the extremely simple equation,

$$E = \frac{c'_{max.} \times E'}{c_{max.}}$$

whose figuring is possible without any difficulty. As we have already shown the quantities $c_{max.}$ and $c'_{max.}$ must be replaced by their professional values. How these can be readily estimated in cases where table II. is not available will be shown by examples.

Of course, the above formula for E has been deduced under the supposition that the visual field and muscular action remains normal. The same method may be readily used for finding the reduced visual field or reduced value of the ocular muscles. Indeed, the reduced quantities P and M, which were omitted in our last formula for the earning ability E, will form with the same amount part of the auxiliary quantity E' and are taken as such in our

table, which furnishes the visual acuities of c_1 and c_2 with remainders of P and M, the value E′. Therefore, we do not need to estimate the impairments of P and M separately.

In order to quickly ascertain in all cases of weakness of vision, the corresponding ability of earning, the following has to be done:

We take the earning ability E′ belonging to the really existing visual acuities c_1 and c_2 from one of the corresponding tables, figure the modified acuities of vision $c_{max.}$ and $c'_{max.}$, multiply E′ with the greater figure $c'_{max.}$ and divide the product by the greater of the two values c_1 and c_2 ($c_{max.}$), but the two quantities $c_{max.}$ and $c'_{max.}$ have to be inserted in their professional values; the resulting quotient is the desired earning ability. To show how simple the calculation really is we will exhibit one example each of the different possibilities which we divide into the following four groups:

Group I—One eye is normal. the other originally weak-sighted.

Group II. Both eyes are originally weak-sighted to equal degrees.

Group III. Both eyes are originally weak-sighted to different degrees.

Group IV. One eye is blind and the other originally weak-sighted.

To each of these four groups may be added the accidental injuries in their different forms. In the following we will explain the single groups with the different accidental possibilities.

§27. *Group I. One Eye is Normal. the Other Originally Weak-Sighted.*

In all the examples of this group we deal with an individual whose work requires higher ocular demands (thus $n = 0.75$) and whose eye 1 has at least a visual acuity of $n_1 = 0.75$ and whose other has perhaps only $n_2 = 0.60$.

Example 1. *The normal eye remains sound ($c_1 = 0.75$). the acuity of vision of the other eye 2 is diminished through an injury to $c_2 = 0.30$ the modified visual acuities are:

$$c_1' = n\,\frac{c_1}{n_1} = 0.75\,\frac{0.75}{0.75} = 0.75,$$

$$c_2' = n\,\frac{c_2}{n_2} = 0.75\,\frac{0.30}{0.60} = 0.375.$$

Table V. of the fourth part gives the earning ability E belonging to $c_1 = 0.75$ and $c_2 = 0.30$ as $E' = 95.41$.

The maximum of the real acuities of vision is $c_1 = 0.75$, of the modified acuities of vision also $c_1' = 0.75$. and as both values correspond according to the table on p. 42 with 1. the desired earning ability E will be: $E = \frac{c'_{max.}\,E'}{c_{max.}} = \frac{1 \times 95.41}{1} = 95.41.$

*In these examples figures taken from tables in Part IV refer to the II German edition of Magnus' book in which the percentages are worked over to the thousandths. For practical use the American Author only accepts them to tenths and has thus published the tables.

EXAMPLE 2. If the eye 1 is sound ($c_1 = 0.75$) while the acuity of vision of the other eye 2, is reduced to $e_2=0$, the modified acuities are:

$$c_1' = n\frac{c_1}{n_1} = 0.75\frac{0.75}{0.75} = 0.75,$$

$$c_2' = n\frac{c_2}{n_2} = 0.75\frac{0}{0.60} = 0.$$

to $e_1 = 0.75$ and $e_1' = 0$ belongs according to table V., part IV., an earning ability $E' = 69.097$.

The maximum of the acuities of vision are as above $e_1 = 0.75$ and $c_1' = 0.75$ to which belongs professionally the figure 1, therefore, the earning ability is:

$$E = \frac{c'_{\text{max.}}\, E'}{c_{\text{max.}}} = \frac{1 \times 69.097}{1} = 69.097.$$

EXAMPLE 3. If the normal eye 1 suffers such an injury that there only remains a visual acuity of $e_1 = 0.50$ while the other eye 2 remains uninjured ($e_2 = 0.60$) the modified acuities of vision are:

$$e_1' = n\frac{e_1}{n_1} = 0.75\frac{0.30}{0.75} = 0.30,$$

$$e_2' = n\frac{c_2}{n_2} = 0.75\frac{0.60}{0.60} = 0.75.$$

Aeeording to table V., part IV., the acuities of vision $e_1 = 0.50$ and $c_2 = 0.60$, for the earning ability $E' = 72.02$ and beeause $c_{\text{max.}} = e_2 = 0.60$, $c'_{\text{max.}} = e_2' = 0.75$ are figures to be replaced by 0.75 and 1, whieh is (see table) the looked-for earning ability:

$$E = \frac{e'_{\text{max.}}\, E'}{e_{\text{max.}}} = \frac{1 \times 72.02}{0.75} = 96.027.$$

EXAMPLE 4. If the normal eye 1 becomes totally blind ($c_1 = 0$) and the other remains uninjured ($e_2 = 0.60$) the modified visual acuities are:

$$e_1' = n\frac{e_1}{n_1} = 0.75\frac{0}{0.75} = 0.$$

$$c_2' = n\frac{c_2}{n_2} = 0.75\frac{0.60}{0.60} = 0.75.$$

whose maximum is $c_2' = 0.75$, while $c_2 = 0.60$ represents the maximum of the real visual acuities. In table V., part IV., we find as belonging to $e_1 = 0$ and $c_2 = 0.60$ an earning ability $E' = 48.925$. so that according to table on p. 42 the figures 1 and 0.75 belong to 0.75 and 0.60 the earning ability is:

$$E = \frac{c'_{\text{max.}}\, E'}{c_{\text{max.}}} = \frac{1 \times 48.925}{0.75} = 65.233.$$

EXAMPLE 5. If both eyes suffer injuries and in 1 there remains only a visual acuity $c_1 = 0.45$, on the other 2 only $c_2 = 0.40$, the modified acuities are:

$$c_1' = n \frac{c_1}{n_1} = 0.75 \frac{0.45}{0.75} = 0.45.$$

$$c_2' = n \frac{c_2}{n_2} = 0.75 \frac{0.40}{0.60} = 0.50.$$

$c_{max.} = c_1 = 0.45$ and $c'_{max.} = c_2' = 0.50$ are figures which correspond (see table, p. 42), with the values 0.50 and 0.5833 to c_1 and c_2. According to table V., part IV., there belongs an earning ability

$E' = 46.284$, the final result is:

$$E = \frac{c'_{max.}\ E'}{c_{max.}} = \frac{0.583....46.248}{0.50} = 53.956$$

§28. *Group II. Both Eyes are Originally Equally Weak-Sighted.*

In the following cases we will suppose that the trade has only small ocular requirements ($n = 0.50$) and that the workman originally possessed visual acuity of only $n_1 = n_2 = 0.40$ in both eyes.

EXAMPLE 1. If eye 1 be uninjured ($c_1 = 0.40$) and the other suffers an impairment to about $c_2 = 0.20$, the modified visual acuities would be according to the following formula:

$$c_1' = n \frac{c_1}{n_1} = 0.50 \frac{0.40}{0.40} = 0.50.$$

$$c_2' = n \frac{c_2}{n_2} = 0.50 \frac{0.20}{0.40} = 0.25.$$

of which the maximum is $c'_{max.} = c_1' = 0.50$, while the real acuities are $c_{max.} = c_1 = 0.40$. According to table VI., part IV., c_1 and c_2

$$E' = 73.338.$$

and as the values according to table, p. 42, correspond to the figures 1 and 0.777 . . . , the resulting earning ability is:

$$E = \frac{c'_{max.}\ E'}{c_{max.}} = \frac{1 \times 73.338}{0.777\ \ldots} = 94.292.$$

EXAMPLE 2. If one eye be totally blind ($c_2 = 0$) while the other be uninjured ($c_1 = 0.40$), the modified acuities are as follows:

$$c_1' = n \frac{c_1}{n_1} = 0.50 \frac{0.40}{0.40} = 0.50.$$

$$c_2' = n \frac{c_2}{n_2} = 0.50 \frac{0}{0.40} = 0.$$

as above, $c_{max.} = c_1 = 0.40$ and $c'_{max.}\, c = 0.50$; table VI., part IV., gives as belonging to c_1 and c_2, $E' = 54.538$, and as a working valuation we get for the earning ability:

$$E = \frac{c'_{max.} \times E}{c_{max.}} = \frac{1 \times 54.538}{0.777\ \ldots} = 70.12.$$

Example 3. If both eyes suffer the same injury so that there only remains a visual acuity of $c_1 = c_2 = 0.20$ then the modified acuities develop as follows:

$$c_1' = c_2' \; n \frac{c_1}{n_1} = n \frac{c_2}{n_2} = 0.50 \frac{0.20}{0.40} = 0.25.$$

in which equation $c_{max.} = c_1 = c_2 = 0.20$ and $c'_{max.} = c_1' = c_2' = 0.25$, to which figures belong the working values of 0.333 . . and 0.4444 . . . For c_1 and c_2, table VI., part IV., we find an earning ability of $E = 29.865$, from which we find the real earning ability:

$$E = \frac{c'_{max.}\ E'}{c_{max.}} = \frac{0.444\ \ldots\ldots\ 29.865}{0.333\ \ldots} = 39.82.$$

Example 4. If the injuries in both eyes are different, the resulting acuity of $c_1 = 0.20$ and of $c_2 = 0.30$ we find that the modified acuities of vision $c_{max.} = c_2 = 0.30$, which are professionally 0.555 . . . (p. 42), the calculation for the modified vision would be:

$$c_1' = n \frac{c_1}{n_1} = 0.50 \frac{0.20}{0.40} = 0.25.$$

$$c_2' = n \frac{c_2}{n_2} = 0.50 \frac{0.30}{0.40} = 0.375.$$

in which the maximum is $c'_{max.} = c_2 = 0.375$; and as this figure is exactly between 0.40 and 0.35, the middle value of the professional quantities 0.777 . . . and 0.666 . . . , *i. e.*, 0.7222 will correspond. To c_1 and c_2 belongs $E' = 51.228$, the earning ability is:

$$E = \frac{c'_{max.}\ E'}{c_{max.}} = \frac{0.722\ \ldots\ldots\ 51.228}{0.555\ \ldots\ .} = 66.596.$$

§29. *Group III. Both Eyes of the Individual are Originally Weak-Sighted to a Different Degree.*

In the following cases we deal with workingmen whose professions have high visual requirements ($n = 0.75$) but who have original visual acuity in one eye $n_1 = 0.65$ and in the other $n_2 = 0.55$.

EXAMPLE 1. Eye 1 is uninjured ($e_1 = 0.65$) while the visual acuity in the other has been impaired by injury to $e_2 = 0.20$, the modified acuities are:

$$c_1' = n \times \frac{c_1}{n_1} = 0.75 \times \frac{0.65}{0.65} = 0.75.$$

$$c_2' = n \times \frac{c_2}{n_2} = 0.75 \times \frac{0.20}{0.55} = 0.27.$$

the maximum $c'_{max.} = c_1' = 0.75$, while we get for the maximum of the real acuities $c_{max.} = c_1 = 0.65$. The first value should be replaced professionally by 1 according to the table on p. 42; the second by 0.833 . . . To c_1 and c_2, table V., part IV., furnish us the quantity $E' = 77.079$, the earning ability is therefore:

$$E = \frac{c'_{max.}\ E'}{c_{max.}} = \frac{1 \times 77.079}{0.8334....} = 92.945.$$

EXAMPLE 2. If one eye becomes totally blind ($e_2 = 0$) while the other remains uninjured ($e_1 = 0.65$), the modified acuities are:

$$c_1' = n \times \frac{c_1}{n_1} = 0.75 \times \frac{0.65}{0.65} = 0.75.$$

$$c_2' = n \times \frac{c_2}{n_2} = 0.75 \times \frac{0}{0.55} = 0.$$

$c_{max.} = c_1 = 0.65$ and $c'_{max.} = c_1' = 0.75$; table V., part IV., shows for c_1 and c_2, $E' = 55.519$, the professional values are the same as in the former example; the earning ability is:

$$E = \frac{c'_{max.}\ E'}{c_{max.}} = \frac{1 \times 55.519}{0.833\ \ldots} = 66.623.$$

EXAMPLE 3. If both eyes suffer injuries of which the vision of one eye is reduced to $e_1 = 0.50$, and in the other to $c_2 = 0.40$, where $c_{max.} = c_1 = 0.45$ (professionally $c_{max.} = 0.50$), the modified acuities are according to the following formula:

$$e_1' = n \times \frac{c_1}{n_1} = 0.75 \times \frac{0.45}{0.65} = 0.52.$$

$$c_2' = n \times \frac{c_2}{n_2} = 0.75 \times \frac{0.40}{0.55} = 0.56.$$

whose maximum $e'_{max.} = c_2' = 0.56$, which professionally represents a valuation of (table V.)*

$$\frac{100 e_2' - 15}{60} = \frac{100 \times 0.56 - 15}{60} = 0.6833\ldots$$

*The professional values belonging to the scientific visual acuities are obtained by the following formula:

Group I. $\frac{100 c - 15}{60}$ Group II. $\frac{100 c - 5}{45}$

To c_1 and c_2 belong according to table V., part IV., E = 46.248, from which we deduce the earning ability of:

$$E = \frac{c'_{max.}\, E}{c_{max.}} = \frac{0.6833 \ldots . 46.248}{0.50} = 63.206.$$

EXAMPLE 4. If both eyes be injured, but in such a manner that one becomes totally blind $c_1 = 0$, while the other is reduced to $c_2 = 0.30$, the modified acuities of vision have the following values:

$$c_1' = n \times \frac{c_1}{n_1} = 0.75 \times \frac{0}{0.65} = 0.$$

$$c_2' = n \times \frac{c_2}{n_2} = 0.75 \times \frac{0.30}{0.55} = 0.41.$$

$c_{max.} = c_2 = 0.30$ (professionally $= 0.25$) and $c'_{max.} = c_2' = 0.41$ (to be replaced by $\frac{100 \times 0.41 - 15}{60} = 0.433 \ldots$) and as belonging to c_1 and c_2, we take from table V, part IV, E' = 13.091, which quantity allows us for the ability to earn:

$$E = \frac{c'_{max.}\, E'}{c_{max.}} = \frac{0.433 \ldots . 13.091}{0.25} = 22.691.$$

§30. *Group IV. In These Cases One Eye Was Originally Blind and the Other Weak-Sighted.*

We suppose that we have to deal with an individual whose profession has only low visual requirements ($n = 0.50$). The one eye is totally blind ($n_1 = 0$) while the other possesses a visual acuity of $n_2 = 0.45$.

If the seeing eye be injured and there remains only a visual acuity of $c_2 = 0.25$, because $c_1 = 0$ has to be used, there is $c_{max.} = c_2 = 0.25$ (professionally $= 0.444 \ldots$) and the modified acuity of vision $c_1' = 0$, the maximum of both values will be:

$$c_2' = n \times \frac{c_2}{n_2} = 0.59 \times \frac{0.25}{0.45} = 0.28 \ldots$$

which corresponds professionally with the figures:

$$\frac{100 \times 0.28 - 0.5}{45} = 0.511 \ldots$$

To c_1 and c_2 belong according to table XVI., part IV., E' = 39.582; the earning ability is therefore:

$$E = \frac{c_{max.}\, E'}{c_{max.}} = \frac{0.511 \ldots 39.582}{0.444 \ldots} = 45.519.$$

CHAPTER XIII.

THE LOSS OF ONE EYE THROUGH ACCIDENT.

Claims for damages in the case of accidental loss of an eye are of frequent occurrence and we will therefore give this subject exhaustive consideration.

§31. *Estimation of the Vision in the Case of the Loss of One Eye.*

In Chap. VI., § 11, p. , we gave the following professional calculation for the binocular act of vision. Our object is now to estimate in what manner the individual factors of the formula are impaired in value by the total loss of one eye. The formula for the binocular act was:

$$S_2 = C \sqrt{P} \sqrt[4]{(m_1\, m_2\, m_3\, m_4\, m_5\, m_6)\quad (m_1'\, m_2'\, m_3'\, m_4'\, m_5'\, m_6')}$$

In the case of the loss of one eye, the central acuity (C of our formula), is so little affected that the slight loss from the taking away of the vision in one eye may be ignored. The clearness of sight is just as good in monocular vision as in binocular. Zehender (54, p. 628) says that the one-eyed condition does not offer any obstacles for following a trade from the visual point of view, but this expression should be understood as only pertaining to the visual acuity and not to the other factors. We, therefore, put the visual acuity in such cases with the valuation of the trade. Of course, we must remember that diminution of the acuity a little below the scientific standard but not encroaching on the trade limits, should not be regarded as injury incurring a liability, for we have shown in Chap. VI., § 12, that a visual acuity of 0.75—0.50 should be regarded professionally as normal. In professions with higher visual demands, a visual acuity of 0.75 is regarded as normal equals 1, and in trades with smaller demands a visual acuity of 0.50 is regarded as normal equals 1. If the injured person have a visual acuity of 0.75 or 0.50 we should not immediately state that his working powers have suffered but should examine into the visual requirements of his trade. If we believe, that the vocation requires fine vision, we would regard a visual acuity of 0.75 as normal, but if the eye work is less, 0.50 may be regarded as normal or 1.

The peripheric vision is but little affected through the loss of one eye, because the extent of the monocular field of vision is but a little narrower than that of the binocular field. Only one segment is missing after the loss of one eye. According to our arrangement of the entire field of vision into three concentric zones

(plate IV., Fig. 1), the loss would be one-sixth of the whole field (either the blue or the red part of the drawing.) Therefore, after the loss of one eye five-sixths of the field would remain which we would insert into the formula as $\sqrt{\frac{5}{6}}$ P.

The action of the muscles will be materially impaired, because estimation of distances, stereoscopic vision and judging of dimensions are dependent upon binocular vision and are lost when it is disturbed, but these functions are only temporally lost. A child losing an eye at an early age, learns immediately to estimate distances, dimensions and relations of objects; an adult recovers more or less of these functions, and as a rule in a very short time; for dimensions, distances, etc., are known to him through his former experience with binocular vision. The muscular sense becomes more developed for the remaining eye, and the estimation of distances and size of objects is restored. Although Mooren (29) disregards that, our own rather considerable experience would allow us to relate of numerous persons who finally had these functions restored so that they were ultimately able to estimate distances, the form and the relation of objects just as well as persons with two eyes. Similar experiences have been noted by other authors (Guillery 14, p. 215). Besides this, we find enough one-eyed persons in every trade who can do their duties as well as those who have two eyes. In an examination (Nieden, 31), of 85,000 miners in Bochum, 310 one-eyed persons were found who could follow their trade as well as the others. As a result of this examination the management of the mines in the Bochum district does not now regard the one-eyed condition as an obstacle for the mining trade, and one-eyed persons are accepted as miners, and those who lose an eye while working are allowed to remain. Under certain circumstances an exceptional individual may be found who does not regain the functions in question to a sufficient extent, but as a general rule the muscular disorders from the loss of one eye are only temporary, and in figuring impairment of the earning ability this should be considered. For a time we may give this impairment an expression in our calculation, but it should be reduced or removed in calculating the latter conditions. One year is sufficient liberal allowance for the individual to adapt his monocular vision to the demands of his profession. A re-examination and new calculation may be made one year afterwards, and the parties interested in the case should be informed that the allowance would be less after one year.

To form the muscular action M into an arithmetical quantity, we divide it into three separate functions, which we intend to regard as of equal value; *i. e.*, 1. into the part for moving the right eye; 2, the left eye; 3, the binocular part. For our purposes both eyes must be regarded as of equal value. When one eye becomes blind, the third part used to estimate distances, etc., is entirely omitted,

but the other two factors remain, even if one only has to do with the movement of a blind eye or of a stump, for in the latter case it serves as a support for an artificial eye, therefore, the muscular action remaining in the case of loss of one eye would be entered into the formula for the act of vision as:

$$\sqrt[4]{\frac{2}{3}}\,\mathrm{M.}$$

The formula for working vision in the case of monocular blindness would be:

$$\mathrm{S} = 1\,\mathrm{C}\sqrt{\frac{5}{6}\,\mathrm{P}}\sqrt[4]{\frac{2}{3}\,\mathrm{M.}}$$

It should be remembered that in professions with higher visual demands the visual acuity C should be regarded as 1 even if it is only three-fourths of the scientific standard and in lower demands it is considered as of normal value if only one-half of the scientific standard.

§32. *Estimation of the Ability to Compete after the Loss of One Eye.*

In estimating the ability to compete after the loss of one eye, the impaired values of the different factors entering into the act of vision should be considered (Chap. VII., § 15). The value of the visual field would be $\sqrt{\frac{5}{6}\,\mathrm{P}}$ and of the muscular action $\sqrt[4]{\frac{2}{3}\,\mathrm{M.}}$

The central acuity, from the professional standpoint, is not considered to have suffered, but still there is an impairment of the earning ability (Chap. VI., § 11, p. 33.) The formula for the ability to compete is taken as a root value, as it is of less importance than the others, and its exponent is made a changeable one, to agree with the seriousness of the ocular injury, as we have shown in Chap. VII., § 15, p. 48. We will briefly refer to these conditions: The ability to compete is dependent not only on the condition of the ocular apparatus of the particular individual but also, and even much more, upon the judgment of the employer. According to the seriousness of the injury, the employer becomes more rigid, and if one eye be lost will even refuse work on this account. An employer may be willing to employ individuals with slight ocular disorders, but will frequently draw the line with the one-eyed. He may occasionally employ a one-eyed man for rough work, but for finer work will always prefer a man with two eyes. There may be exceptions, as there may be employers who regard one-eyed individuals as able as normal sighted ones, but a normal sighted one will

most always be preferred. These conditions must not be overlooked in order to do justice.

The ability to compete, according to our conception, is a proper fraction, because it is a product whose factors are either proper fractions or equal to 1. If a proper fraction be taken as a root we are able to raise or diminish its value by choosing the exponent of the root: with a raising exponent the root value enhances, and vice versa. If we adapt the ability to compete in one case as the 10th root and in another as the 5th root, in the first case the value would be greater and in the latter smaller. Thus by enhancing the ability to compete, the earning ability increases while the other way it diminishes. If in the case of slighter injuries we use the exponent 10; by taking a smaller exponent, for instance, 5, to reduce its own and the value of the earning ability, it would meet the requirements of the loss of one eye in those trades having higher visual demands, whereas for coarser trades we may take 7 as the exponent. (See Chap. VII., § 15, p. 48). In the first case, we would get for the ability to compete the following expression:

$$\sqrt[5]{\frac{1\,C+0}{2}}\ \sqrt{\frac{5}{6}\,P}\ \sqrt[4]{\frac{2}{3}\,M},$$

and in the second case

$$\sqrt[7]{\frac{1\,C+0}{2}}\ \sqrt{\frac{5}{6}\,P}\ \sqrt[4]{\frac{2}{3}\,M}.$$

§33. *Estimation of the Earning Ability Where One Eye Becomes Blind.*

According to the formula for the earning ability $E = F + \sqrt[x]{K}$.

I. In professions with higher visual demands for the first year after the injury:

$$E = 1\,C\ \sqrt{\frac{5}{6}\,P}\ \sqrt[4]{\frac{2}{3}\,M}\ \sqrt[5]{\frac{1\,C+0}{2}}\ \sqrt{\frac{5}{6}\,P}\ \sqrt[4]{\frac{2}{3}\,M},$$

and after the first year:

$$E = 1\,C\ \sqrt{\frac{5}{6}\,P}\ \sqrt[4]{M}\ \sqrt[5]{\frac{1\,C+0}{2}}\ \sqrt{\frac{5}{6}\,P}\ \sqrt[4]{M}.$$

II. In professions with lesser visual demands for the first year after the injury:

$$E = 1\,C \sqrt{\tfrac{5}{6}\,P}\ \sqrt[4]{\tfrac{2}{3}\,M}\ \sqrt[7]{\tfrac{1\,C+0}{2}}\ \sqrt{\tfrac{5}{6}\,P}\ \sqrt[4]{\tfrac{2}{3}\,M},$$

and after the first year:

$$E = 1\,C \sqrt{\tfrac{5}{6}\,P}\ \sqrt[4]{M}\ \sqrt[7]{\tfrac{1\,C+0}{2}}\ \sqrt{\tfrac{5}{6}\,P}\ \sqrt[4]{M}.$$

The calculation of these formulas has been made, by the assistance of our curves, so simple that it is reduced almost to common multiplication. Let us figure the first formula:

$$E = 1\,C \sqrt{\tfrac{5}{6}\,P}\ \sqrt[4]{\tfrac{2}{3}\,M}\ \sqrt[5]{\tfrac{1\,C+0}{2}}\ \sqrt{\tfrac{5}{6}\,P}\ \sqrt[4]{\tfrac{2}{3}\,M}.$$

C the central maximal visual acuity remains 1; $\sqrt{\frac{5}{6}P}$ may be read on plate V without difficulty; as more convenient we change the fraction $\frac{5}{6}$ into a decimal—0.833, and $\sqrt{}$ 0.833 P according to our curves equals 0.913. $\sqrt[4]{\frac{2}{3}\,M}$ being changed into a decimal 0.666, is found on plate V. as 0.904. The equation for the ability to compete* would thus be:

$$\sqrt[5]{\tfrac{1\,C+0}{2}}\ \sqrt{\tfrac{5}{6}\,P}\ \sqrt[4]{\tfrac{2}{3}\,M}$$

should be first figured into its single factors before we can find the total value in plate III.; when we do this, we get for the central acuity $\frac{1\,C+0}{2}$ the value equals 0.50; $\sqrt{\frac{5}{6}\,P} = 0.913$ and $\sqrt[4]{\frac{2}{3}\,M} = 0.904$. The equation for the ability to compete would thus be: $\sqrt[5]{0.50 \times 0.913 \times 0.904} = \sqrt[5]{0.4127}$ and this figure we

*In the general formula for the ability to compete $\sqrt{\frac{C_1+C_2}{2}}\ \sqrt{P}\ \sqrt[4]{M}$ the factors C_1 and C_2 should always be replaced by their professional valuation.

find on plate V., curve 3, the valuation equals 0.838. We state again the original formula:

$$E = 1\,C\,\sqrt{\frac{5}{6}}\,P\,\sqrt[4]{\frac{2}{3}}\,M\,\sqrt[5]{\frac{1\,C+0}{2}}\,\sqrt{\frac{5}{6}}\,P\,\sqrt[4]{\frac{2}{3}}\,M,$$

which has been reduced to: $1 \times 0.913 \times 0.838 = 0.69145$, which in percentage is 69.145 per cent., which is the full earning ability and therefore its impairment is 30.855 per cent. Should we have worked this equation out entirely by figures, we would have found the values 69.097 per cent. and 30.903 per cent., which differ immaterially from those given by our curves. This example shows that our curves simplify the calculation without materially changing the results.

According to our calculations for trades with higher visual demands we find that a one-eyed person after being cured of the ocular disease has an impairment of the earning ability amounting to 30.903 per cent., and after one year of 21.966 per cent., while for vocations demanding less vision the values would be 27.315 per cent. and 18.388 per cent. Of course, it would be left to the management of the Insurance Companies as well as to the physician to change these proportions more or less according to the circumstances of the case. *Approximately we may say that a one-eyed person has lost 30 per cent. of his earning ability for the first year after the accident and 20 per cent. afterwards for the higher class of trades and for the lower class the proportion would be 27 per cent. for the first year and 18 per cent. thereafter.* Certainly there is a difference between the individual who has been employed in fine handiwork and one doing common manual labor, and justice demands that a difference should be made in judging the indemnity. The system in vogue was an unfair one, as it over-estimated the valuation for the loss of one eye, the Imperial Insurance Office (3) having given 33 1-3 per cent. indemnity. Heddäus (18) had fixed the indemnity at 25 per cent.; Groenouw (12) accepts the sliding scale as made by Magnus, his values fluctuating between 20 and 30 per cent., and are therefore very close to the indemnity proposed by Magnus; but they must be regarded solely as arbitrary estimations and not the result of exact calculations as have been given in this book. Examination of all one-eyed persons in the iron and steel trades in certain districts in Germany showed that there was an actual impairment in the amount of work done and the wages earned of 26 per cent. at the highest (Magnus, 26). Examination of the Miners' Association in Halle a. S. (41) showed only 20 per cent.

All these facts speak for a revision of the 33 1-3 per cent. rate now granted by the German Insurance offices. No real difference should be made for the values of the right or the left eye, although it is shown that the left eye is injured much more frequently (Ot-

tinger 33, p. 76); the left eye being injured in 60.2 per cent and the right in 39.8 per cent. It would be perhaps well for the workman after losing the less endangered right eye to avoid vocations in which injuries to the eye are frequent.

Our valuations of 30.903 per cent. and 27.315 per cent. admit after one year of a reduction, because those muscular functions which were formerly executed by both eyes are partly or entirely restored. The figures of 21.97 per cent. or 18.39 per cent. should be regarded as the maximal limit to which the damage may be reduced. This reduction should not be obligatory in every case but the individual should receive full consideration. In the case of older men, a reduction may perhaps never be made because an old man will never acquire new functions as will the younger one. The intelligence of the person is a factor and the profession itself should play a rôle as regards this reduction of damage, depending upon the visual demands of the vocation. In the case of smaller ocular demands we need not be so considerate.

A further important question is whether the sudden total loss of one eye does not demand a different valuation for the earning ability than gradual growing blindness on one side. Accidental blindness may be caused in different ways; either the eye may be injured to such an extent that sight is immediately lost or the injury produces a diseased condition leading gradually to the loss of vision. There are numerous cases in which passable visual acuity exists for some time after the accident and blindness only develops after several years. Such cases occur from blows upon the head causing rupture of the posterior coats of the eye, causing ultimate detachment of the retina through cicatricial contraction. Iron and copper splinters in the interior of the eye may, after one or two years, cause blindness. Sudden blindness in one eye has certain ocular consequences which make the following of the profession more difficult for the injured, *i. e.*, the judgment of distances, etc., and should be considered in estimating the impairment of the earning ability. If the one-sided blindness develops gradually, the lapse of time permits the injured person to adapt himself to the ocular consequences of being one-eyed. It is, therefore, not more than fair to consider these conditions in figuring the impairment of the earning ability. We would, therefore, figure the impairment of the earning ability in a case of gradual loss of sight at the lower rates above given. *Therefore the impairment of the earning ability from the gradual loss of the sight in one eye following an accident in trades of higher visual demands is 21.97 per cent., in professions with lower visual demands 18.39 per cent.*

There was a time when 50 per cent. was regarded as the valuation for the loss of one eye (Mooren 29: Golebiewski 10, pp. 129 and 241). But this is only a matter of history, for when the subject of economic damage from the loss of one eye was first preached, the valuation of the two eyes was placed at 100, and one-half

or 50 per cent. taken off for one eye. There was no scientific ophthalmologic investigation of the question, and it was believed that the factors for fixing the amount of annuity or damage should be looked for mainly in the philanthropic-philosophical and not in the ophthalmologic professional sphere. Zehender's (53) 33 1-3 per cent. and Jatzow's (19a) 40 per cent. are estimations based upon psychic factors. The executive boards of the insurance offices and societies generally prefer a much lower indemnity (Moses 30, p. 23). It is very likely that the present 33 1-3 per cent. rate will share the fate of the 50 per cent. rate and soon will be replaced by a scientific standard such as we have given it. Our methods are based upon scientific principles and give the workingman of all classes pro rata indemnity corresponding to the amount of the damage to their working powers. The employer certainly finds in our system a protection against unfair claims of the employed. The badly injured person is really better off under our system, for our "total disability of earning" begins with a visual acuity of below one-seventh to one-twentieth, whereas the old system total disability was when the vision was under one-hundredth. It is, therefore, just and fair for both employer and employed.

§34. *Concerning the Supposed Greater Danger of a One-Eyed Person Becoming Totally Blind and Its Relations to Indemnity.*

Perhaps the reader, in our calculation of the impairment to the earning ability, may have already missed any reference or consideration of the ultimate blindness or of the greater danger of becoming blind for the one-eyed person, upon which has been laid such stress by Zehender (53, p. 269). We do not consider, as he does, that this danger under all circumstances is double that of the normal person, for the risk is but little greater. For instance, the most frequent cause of blindness between the ages of 15 and 45 years is atrophy of the optic nerve (Magnus 24, p. 246) and from 45 to 60 it is glaucoma; but we must remember that it is the general rule for atrophy of the nerve to be double-sided. The causes of one-sided atrophy are very rare and are very different pathologically from the binocular ones. There is precisely the same danger from this disease. Zehender's philantrophic feeling brought him in glaring antagonism to statistics. All he should have said was, that the possibility of becoming blind in certain diseases and especially in certain injuries of the eyes is greater in the one-eyed person, for, when the normal human being loses one of his eyes by an accident, he, of course, retains the sight of the other, while the one-eyed person in losing his one eye becomes totally blind. Theoretically there is nothing to be said against this conclusion, but practically it is not of much importance. Our experiences show that but few one-eyed persons lose their other eye through an injury

and, at any rate, these are so few that there is certainly not double the danger of becoming blind. Magnus (24, p. 184) states that only once within the last eight years has he seen a one-eyed person whose sound eye was injured by an injury; a fact which is surprising in view of the numerous losses of one eye of normal-sighted. Würdemann, practicing in a manufacturing district where ocular accidents are common, has seen but two cases of the loss of the remaining eye of a one-eyed person by accident within the last ten years. The general experience of other practitioners will surely support the above statements. We do not think that this question should allow of additional indemnification in relation to figuring the accident insurance or the annuity to be granted in any case to workmen. Accidents to the remaining eye are more rare than to persons who have two eyes, for in the first place they have learned to be particularly careful to shield the remaining eye from injury and to use it properly. We know one-eyed persons in many vocations, in some of which the liability to ocular accidents is frequent, for instance, workmen in stone quarries, in mines, in machine shops, etc., but we have never heard from any one that the concern about his one eye hindered him in his profession. Complaints of one-eyed persons are generally quite different and refer to disorders in judging distances, etc.; often such persons, who try to exaggerate their injury, use other means than the concern regarding their remaining eye. We must, therefore, exclude the danger of becoming blind under all circumstances; in calculating the impairment of the earning ability of the one-eyed person the question of sympathetic inflammation should be considered from the same point of view, but this is so important that we will treat it in a separate chapter. (Chap. XVI.)

CHAPTER XIV.

§35. *Accidental Injuries of the Crystalline Lens. Aphakia.*

In injuries of the crystalline lens we have the peculiar condition that as long as the injury lasts and the opaque lens stops the function of sight, there is no doubt regarding the extent of the impairment to the earning ability, but as soon as the injured lens is taken out by an operation which clears the pupil and vision returns, then difficulties appear in the calculation. We have had occasion to study many opinions and decisions in order to make satisfactory judgment of the results of aphakia upon the working powers. If one eye be normal and the other became aphakic through the loss of the lens, the unequal refraction of both eyes renders the vision practically monocular, as the lensless eye is so hyperopic that a concert of action of both eyes for professional use cannot be had; even though the refraction be neutralized by convex glasses it cannot work together with the sound eye, and the subject will always prefer to dispense with the visual acuity on the lensless side and work with the normal eye. We, therefore, as long as the other eye remains sound, regard one-sided aphakia in the same manner as that of an individual having suffered important injuries to the visual acuity while the visual field and the muscles remain normal. This assertion cannot be changed by the fact that eventually the visual acuity of the aphakic eye may be one-half or more; for if the individual cannot make use of this acquired acuity of vision in the injured eye, his success in earning remains exactly the same as if the visual acuity were not sufficient for use. Therefore we put monocular aphakia in the same position as the eye whose central acuity is impaired to a high degree and reduced to 0.15 in professions with higher, and to 0.05 in professions with lower ocular demands. But we do not consider such an eye in the same relation as one which is blind, for it forms, as Fuchs says (8a), "A reserve for the future." But if the operative removal of the lens had not given a satisfactory result regarding regaining good vision, such an aphakic eye would not represent a prospective reserve for the future and should be considered as professionally blind. Thus the valuation of the relations of the aphakic eye to the earning ability may be made upon sound principles and with due regard to the individual peculiarities of the case. Tables V. and VI. of part IV. give information regarding the impairment of the earning ability in the case of one-sided aphakia. The conditions are as follows: If an aphakic eye has a visual acuity of 0.15 and over, in professions with higher visual demands, and of 0.05 and over, in professions with lower visual demands, and if the other eye remains normal, the impairment to the earning ability would be 6.69 per cent. But if the aphakic eye has a

visual acuity below 0.15 or 0.05, depending upon the character of the vocation, the impairment of the earning ability would be in the first case 21.9 per cent. and in the latter case 18.3 per cent (tables V., and VI., part IV.) These figures may be reduced to 15.5 per cent., depending upon individual circumstances. For instance, if the injured person is young and gets along easily with the changed ocular conditions, the lower figure may be chosen; the employment of the injured person, his mental capacity and other factors will play a rôle in choosing the higher or the lower figures. These are all conditions which should be considered in every case and left to the decision of the trade boards or the physicians. The foregoing refers to cases where one eye remains sound; but if a man loses a lens and the uninjured eye was previously weak-sighted, the conditions are certainly different. If the uninjured eye cannot be used for working purposes, the aphakic eye has to be estimated as if the individual had been one-eyed. We here start from the fact that the impairment of the earning ability is determined by the central acuity of vision which the aphakic eye has regained. If the originally weak-sighted and uninjured eye is still able to earn, we have to regard, in the professional estimation, the extent of the central acuity which both eyes possess. The eye which is used and which possesses the highest degree of acuity must be regarded as most fitted for earning while the other should be regarded as excluded from work on account of the difference in the refraction: the calculation is then made according to the principles put down in Chapter XII.

There are still cases possible, and we know of such, in which an individual who became aphakic on one eye through an accident has later lost the remaining eye through another accident. The calculation of the impairment of the earning ability would then have to start from the central acuity of vision of the aphakic eye which is fully explained in tables V. and VI.

CHAPTER XV.

§36. *Injuries of the Eyelids, Conjunctiva and Cornea.*

Traumatisms of the eyelids, conjunctiva and cornea may hinder vision and their influence may be measured by the diminution of the central acuity and the other factors of the visual act. We have shown how burns may lead to extensive symblepharon and hinder the ocular movements. In one case Magnus notes where the symblepharon was entirely relieved by operation, the eyelid remained thickened, reddened and without eyelashes and the conjunctiva was readily irritated. The disfigurement of the lower lid was such that the patient could only get new work with difficulty and when he obtained a job would soon have to give it up again, as the least irritation produced a flow of tears which made continuation of work impossible. Notwithstanding that he had almost normal visual acuity he had to be regarded as impaired for work. The valuation of such a case had to be left entirely to the physician. We would here warn against over-estimation of disfigurements; it frequently happens that persons who have lost one eye by a serious accident are not satisfied with the annuity, indemnity or amount of insurance that has been paid them and on account of disfigurement may claim a higher rate, which in certain cases has been given to them. Magnus does not consider such a course justifiable, for by his method in the valuation of the loss of one eye, the disfigurement connected therewith is already considered. We have done this in our previous pages by giving the proper valuation in such cases to the ability to compete.

CHAPTER XVI.

§37. *Should the Danger of Sympathetic Ophthalmitis be Considered in Estimating the Impairment of the Earning Ability?*

The possibility of resultant sympathetic disease in the uninjured eye has been brought up many times in medical and trade assembly circles and in the law courts in estimating the impairment of the earning ability. A number of authorities have considered that this factor was of considerable moment in allowing an increase of the rating; especially if there is a foreign body in the eye there is even a disposition to give these conditions an expression in the amount of the rating. We do not think that this danger should influence the amount of the impairment allowed of the earning ability. The possibility of being insured against sympathetic inflammation should be undertaken by the laborer himself, the same as one pays a premium for fire insurance, if it is to be considered at all. Such a relation between the employer and the employed cannot be thought of; but if there was positive danger of future sympathetic inflammation it might possibly be considered in calculating the impairment to the earning ability, if it really exerts a hindering influence upon the workman's powers; for instance, if the man has to be exceedingly careful not to heighten that danger or to hasten the outbreak of inflammation and thus has to limit the amount of work or his working hours, an addition to his annuity or indemnification might be justifiable and these conditions should be considered. But the factors which affect the outbreak of sympathetic ophthalmitis are not to be looked for in the performance of the work and are not favored through the uses of the eye connected with working life. This has been shown by experience. The youthful eye which has not been used very much in working seems to be more exposed to sympathetic ophthalmia than the older eye. The danger of sympathetic ophthalmitis is greatest in the first few months after the injury of the other eye, and then it materially diminishes. From the oculist's standpoint, the danger of sympathetic ophthalmitis cannot be regarded as limiting the earning ability, for this danger may be entirely removed if the patient submits to the operation proposed by the physician.

CHAPTER XVII.

§38. *Injuries of the Cornea Through Splinters of Iron or Foreign Bodies.*

Injury to the cornea through splinters of iron or emery is perhaps the most common accident. Special difficulties are not found in applying our rules to such conditions. Most frequently the cornea is injured by small particles of metal, and such cases are common in every oculist's practice and are of daily occurrence in ophthalmologic clinics. As a rule cases are immediately cured after removal of the foreign body and the little scars left are too insignificant to exercise a detrimental influence upon the visual acuity. Of course, many such accidents may have occurred and the cornea be spotted with such small cicatrices, but in the course of time the workingman usually adapts himself to the increasing loss of vision and does not feel the loss professionally. There are only exceptional cases that might be hindered in work by such accidents, and the results are best estimated by the rules pertaining to the estimation of the visual acuity.

CHAPTER XVIII.

§39. *Accidental Impairments of the Accommodation.*

Loss of accommodation without other injuries of the eyes are very seldom caused by an accident. They mostly develop from serious contusions of the head, especially of the forehead, contusions of the iris, etc., and are much more frequently one-sided than double-sided. They may exist without changes of the pupil, but usually there is mydriasis. Such injuries should not be allowed lasting pecuniary compensation, because we are always able to replace the lost accommodation by fitting convex lenses; and as the accident insurance law does not indemnify the lost function itself, but gives a pecuniary compensation only when the earning ability has suffered, the impairment of the accommodation is surely not within the bounds of the accident insurance law, although claim for small damages might be allowed. There are conditions which are in favor of granting at least a small indemnity: for instance, if there be one-sided paralysis of the accommodation as well as of the pupil, the dazzling and the dimness of the images may cause inconvenience; but these symptoms ultimately pass away, for the subject becomes used to the condition, even though at first he is hindered by such symptoms. One-sided paralysis of the accommodation may be remedied by the use of convex glasses; if the injured person opposes wearing these, it is his own look-out, for if he throws away his chance to regain the lost function, by a little inconvenience like the wearing of glasses, he should not have a right for an indemnification based upon the loss of earning ability. Where there is loss of accommodation, the individual character of the case should be considered by the physician, insurance companies and the courts.

CHAPTER XIX.

§40. *Common Diseases of the Eyes of Local Origin That Impair the Earning Power.*

In addition to the subject of injuries to the earning ability caused by traumatism, it has been deemed well to give a brief résumé of common diseases of the eyes of local origin that may impair the earning power. In doing this we quote largely from Hansell. (17)

Acute inflammation of lids and conjunctiva being transitory seldom leads to more than transient disability. The visual power is decreased in proportion to their intensity. By reason of pain, swelling photophobia and discharge, the patient has no earning power during their continuance.

Chronic blepharitis and conjunctivitis without actually lowering the acuity of vision, prohibit sustained near use and cut down the number of daily working hours and proportionately the income.

Acute inflammation of the cornea of one or both eyes totally disables.

Chronic inflammation of the cornea of one or both eyes totally disables.

Opacities of the cornea of one eye reduce the earning power not more than 30 to 18 per cent. (If one eye be rendered entirely blind for economic purposes by reason of corneal opacity, it may be treated as a case of monocular blindness, the impairment of the earning ability for which ranges between 18 and 30 per cent., Chap. XIII., § 33, p. 90.)

Opacities of the cornea in both eyes reduce the earning power according to the visual acuity.

Acute iritis of one or both eyes totally disables for periods of six weeks or longer.

Chronic iritis with posterior synechiæ reduces earning capacity according to the visual acuity, modified by the number of working days or hours according to the peculiarities of the case (50 per cent. by Hansell).

Incipient cataract of one eye, no reduction.

Advancing cataract of both eyes reduces according to the acuity of vision remaining and is subject to continuous retrogression.

Complete cataract in both eyes completely disables, but after successful operation on one eye the case is relegated to the catgory of refractive cases. The earning power is restored according to the vision regained for far and near. Hansell cites a patient operated upon for cataract who stated that his earning power had been gradually reduced from $18.00 per week to nothing. For six

months after cataract extraction his vision had equalled 20|c and he had earned $9.00—50 per cent. loss. Lately he has vision with a new correction 20|xv and has been able to command his old wages.

Vitreous opacities of one eye do not decrease the earning power, unless due to the presence of a foreign body causing irritation and photophobia preventing full working hours, with danger of sympathetic ophthalmia.

Vitreous opacities of both eyes decrease the earning power according to the visual acuity plus the liability to total loss, which may be estimated at 50 per cent. more.

Detachment of the retina spontaneously or in myopia of one eye may be reckoned as total loss of that eye plus the probability in the latter of total loss and total disability. Spontaneous or idiopathic detachment of the retina of one eye is rarely followed by a similar affection in the other, hence the probability of total loss is less. The contrary pertains, however, where it follows as a consequence of scleral stretching and chorioidal atrophy of myopia, when the earning power is seriously menaced. The choice of occupation is rendered difficult, since those demanding prolonged near use of the eyes and straining and stooping positions must be declined.

Other diseases of the retina, the result of purely local causes and limited to one eye, do not decrease the earning power.

Double central retinal chorioiditis reduces the earning power to that of the average laborer, although the periphery of the fields may be intact. Exceptions must be made when the earning power depends upon intellectual rather than ocular acuteness.

Constitutional, acquired, or hereditary ocular disease, such as albuminuric retinitis, retinitis pigmentosa, tubercular choroiditis, syphilitic affections of the cornea, iris, vitreous and fundus tissues, optic nerve atrophy, progressively reduce the earning power in direct proportion to the loss of vision until the patient's death or total disability.

Congenital color blindness debars the individual from army, navy and railroad service, but from few practical pursuits and only by limiting the selection of occupation does it interfere with his earning power. The estimate of the degree is purely arbitrary, but probably does not exceed 1 per cent.

We compute (Chap. IX., § 19. p. 58) the loss of earning power from peripheral limitation of the fields thus:

Loss of 30 degrees..... No loss of e. p.
Loss of 40 degrees.....20 per cent. loss of e. p.
Loss of 60 degrees.....45 per cent. loss of e. p.

Peripheral limitation of one field only entails loss of e. p. of 10 per cent.

In homonymous hemianopsia.....Loss 30 per cent.
In bitemporal hemianopsia.....Loss 20 per cent.
In binasal hemianopsia.....Loss 0 per cent.

Diplopia from monocular paralysis irremediable by prisms but removed by occlusion of one eye brings the patient into the category of the one-eyed, but since a variable amount of time must elapse before the individual is able to resume his previous occupation and to regain his old skill, he suffers a loss during this time of his earning capacity of 18 to 30 per cent. (*i. e.*, economic monoculism is produced; see Chap. XIII., § 33, p. 90).

Paralysis of associated movements and double complete ophthalmoplegia externa completely disables.

Errors of refraction deserve but scant attention in this paper, since they are for the most part remediable, and the individual is subjected to the annoyance only of his dependence on spectacles for the full use of his eyes with good vision. This is an inconvenience, but does not decrease the earning power except as applied to a few occupations. In the absence of disease persons with any kind of regular defects can be restored to full earning power. In the case of an incorrectible accommodative and muscular trouble by which an individual is incapacitated from the full use of his eyes, the loss of earning power will equal the number of hours daily that he is unable to work and may be estimated at 50 per cent. of his full capacity. Conical cornea and irregular astigmatism not being subject to full correction by lenses diminish the earning ability according to the loss of visual acuity.

Foreign bodies in the interior of the eye totally incapacitate for a variable number of weeks and are in the great majority followed by the loss of the eye. If removed before the stage of chronic irritation sets in and the danger of sympathetic ophthalmia is not present, the individual goes into the list of the one-eyed. If allowed to remain the earning power is lessened 25 per cent. and in many cases finally 100 per cent.

Foreign bodies in the cornea are readily removed usually without permanent cicatrices. Before extraction the earning power is reduced 100 per cent. The sudden loss of one eye incapacitates to greater degree for a time than the gradual loss, because the individual loses all judgment of space and he requires time to learn anew the relation of objects to each other and their size and shape, since the mental conceptions are changed. Among the trades that require the higher grades of vision the damage to the earning power in the gradual loss of one eye is 22 per cent., in the lower 18 per cent. Zehender (54) says that after the loss of one eye only two-thirds of the earning capacity remains. Mooren (29) adds to this the loss of binocular vision 8 to 16 per cent., according to the danger of the occupation.

PART THIRD.

Estimation of the Pecuniary Loss to the Individual by Reason of Visual Imperfections.

CHAPTER XX.

§41. *Estimation of the Pecuniary Loss to the Individual by Reason of Visual Imperfections.*

In the foregoing we have estimated the economic damage in the form of percentages. Now it remains to apply these ratings to the conditions met with in daily life.

Money being the world's medium of exchange and of valuing a man's work or time, we must reduce the economic damage in each individual case to its value in dollars and cents or the monetary medium of the country in which the compensation for damage may be sought. It goes without saying that the value of men's time and wages differ greatly, not only in different trades and professions, but even the various members of the same trade receive varying wages.

If we wish to exactly estimate the damage to the individual case, we must, therefore, figure with the compensation that the individual himself has been getting and his probable future earnings. It must be allowed that this may be done in the case of artisans and the working classes generally, and that this estimate may be legitimately used as a basis with which to calculate the pecuniary loss he may sustain by reason of lessened working and earning ability. In the case of professional and business men, who do not receive regular wages or a stipulated income, it might be considered strict justice to the defendant to take the average earnings of the class to which the plaintiff may belong as a basis upon which to figure the indemnity.

It should be likewise considered that an old man cannot lose (as regards earning ability) as much as a younger man, for the elder has fewer prospective years of employment and consequent less money equivalent than the younger. *Thus the age of the plaintiff should always be considered.* It may likewise be taken for granted that the average earning life begins at 15 and ceases at 65 years; that in the case of a business or professional man the wages will be doubled every tenth year until cessation of working life; that in the case of working men this doubling will occur for the first two periods of five years and afterwards the usual rate will be maintained until at the age of 50, and 15 years thereafter though competition of younger men and natural infirmities of this period of life then will be a certain reduction in the wages. Exceptions to this estimate must be made in the case of girls and women, since their working years are fewer and their increase of earnings does not follow the same rule as that of men; many, perhaps the majority, being employed in shops, mills and offices and in such positions that increase of skill and experience are not rewarded by increase of their income.

Hansell assumes (17) that a professional or business man will double his earnings every ten years, provided his mental and physical health is preserved, and that he has average intelligence, industry and ambition. He considers that when the earning power of the individual falls below 66 per cent. of the average earning capacity, that promotion with increase of income cannot be reckoned and that when 80 per cent. of the visual power is lost the man is no longer in a position to earn the income that was his before, and, therefore, not only receives no increase, but his wages thereafter may diminish; and if vision be reduced to counting fingers at 1-3 m. (Magnus 0.15 to 0.05) the loss is 100 per cent., the individual earning nothing and also becoming a charge upon his family or the community. The doubling of the earnings for each decade may be applied as a principle to most business and professional men, but in the case of laborers and artisans, who receive no promotion after having attained a certain grade, it must be modified in respect to the doubling of wages or income every tenth year. This permits of a decided simplification of the computation, for as Hansell says: (17) if a man earns $20.00 a week, and will continue to earn that amount during the remainder of his working years, his loss will depend upon the age at which the incapacity begins and its degree.

The following table, which agrees roughly with the mathematical estimations of Magnus, has been empirically figured by Hansell:

Visual Acuity.	Loss of Earning Capacity.
$^{20}/_{60}$	$^{1}/_{5}$ or 20 per cent.
$^{20}/_{80}$	$^{1}/_{3}$ " 33 "
$^{20}/_{100}$	$^{1}/_{2}$ " 50 "
$^{20}/_{150}$	$^{2}/_{3}$ " 66 "
$^{20}/_{200}$	$^{4}/_{5}$ " 80 "
$^{5}/_{200}$	4.75 " 95 "
Counting fingers at $^{1}/_{3}$ m.	$^{5}/_{5}$ " 100 "

By adjusting Hansell's age scale for the pecuniary earnings to the estimation of the actual damage figured by the method of Magnus we may arrive at an exact mathematical estimation of the economic damage to the individual for the loss of vision in any given case. In the following tables we give the earning power in dollars and cents for the five decades of earning life.

Table C is adapted for the professional and businesss class whose earnings as a rule increase until their retirement from business.

Table D is for the artisan classs whose earnings remain about the same during adult life and at the end of the working period are usually subject to decrease.

Table E is for the laboring classes whose earnings are subject to much the same law as that of the artisan.

TABLE C.

Illustrating the Monetary Valuation of the Remaining Earning Ability in the Case of an Average Professional or Business Man Suffering from Accidental Loss of Visual Acuity; Figured from the Five Decades of Working Life for Vocations Having Higher Visual Demands.

	Individual in health with normal eyes.	LOSS OF VISUAL ACUITY EQUAL IN BOTH EYES AFFECTING EARNING ABILITY.											Sudden blindness of one eye, the other remaining.	
SCIENTIFIC STANDARD OF VISUAL ACUITY.	100. to .75	.70	.65	.60	.55	.50	.45	.40	.35	.30	.25	.20	.15—0	V { R. E.=0 L. E.=1.00 Loss figured at 20%. See page 78.	V { R. E.=0 L. E.=.50 Loss figured at 63 9%. See table 3, part V
Economic valuation of visual acuity. See table B, 1, page 42—Higher Visual Demands.	1.00	.90	.83	.75	.66	.58	.50	.41	.33	.25	.16	.08	0	1.00	0.58
Percentage of remaining earning ability, also value of the ability per hundred in dollars, arranged from the mean of exact figures. Table 5, part V, page 119.	100	90 8	81.8	72 8	64.	55.2	46.6	38.1	29.8	21.7	13 9	6.4	0	80.0	36.1
AGE — Annual income in dollars.															
15 to 25 years (10)..	$ 250	$ 227	$ 204.50	$ 182	$ 160	$ 138	$ 116 50	$ 95.25	$ 74.50	$ 54 25	$ 34 75	$ .6	0	$ 200	$ 90.25
25 to 35 years (10)..	500	454	409.00	364	320	276	233.00	190.50	149.00	108 50	69.50	32	0	400	180.50
35 to 45 years (10)..	1,000	908	818.00	728	640	552	466.00	381 00	298 00	217.00	139.00	64	0	800	361.00
45 to 55 years (10)..	2,000	1,816	1,636.00	1,456	1,280	1,104	932 00	762.00	596 00	434.00	278.00	128	0	1,600	722 00
55 to 65 years (10)..	4,000	3,632	3,272.00	2,912	2,560	2,208	1,861 00	1,524 00	1,192.00	868.00	556.00	256	0	3,200	1,444.00
Total earnings for life after 15 years of age; the first column figured as the full amount that could be earned by the individual during his lifetime, the balance for an injury occurring at 15 years of age.	$77,500	$70,370	$63,395.00	$56.420	$49,600	$42,780	$36,115.00	$29,527.50	$23,095.00	$16,817.50	$10,772.50	$4,960	0	$62,000	$27,977 50

TABLE D.

Illustrating the Monetary Valuation of the Remaining Earning Ability in the Case of an Average Artisan Suffering from Accidental Loss of Visual Acuity; Figured for the Five Decades of Working Life for Vocations Having Higher Visual Demands.

	LOSS OF VISUAL ACUITY EQUAL IN BOTH EYES AFFECTING EARNING ABILITY.													Sudden blindness of one eye, the other remaining.	
SCIENTIFIC STANDARD OF VISUAL ACUITY.	1.00 to .75	.70	.65	.60	.55	.50	.45	.40	.35	.30	.25	.20	.15—0	V {R. E.=0 L. E.=1.00 Loss figured at 20%. See page 78.	V {R. E.=0 L. E.=30 Loss figured at 87%. See table 3, part V
Economic valuation of visual acuity. See table B, 1, page 42.	1.00	.90	.83	.75	.66	.58	.50	.41	.33	.25	.16	.08	0	1.00	0.25
Percentage of remaining earning ability, also value of the earning ability per hundred in money, arranged from the mean of exact figures. Table b, part V, page 119.	100	90 8	81.8	72.8	64.	55 2	46.6	38.1	29.8	21.7	13 9	6.4		80 0	13.
AGE — Annual Income.															
15 to 20 years (5).....	$ 250	$ 227	$ 204 50	$ 182	$ 160	$ 138	$ 116.50	$ 95 25	$ 74.50	$ 54.25	$ 34 75	$ 16		$200.	$32.50
20 to 25 years (5).....	500	454	409 00	364	320	276	233.00	190.50	149.00	108.50	69.50	32		400.	65.00
25 to 50 years (25).....	1,000	908	818.00	728	610	552	466.00	381.00	298.00	217.00	139.00	64		800.	130.00
50 to 65 years (15).....	750	681	613.50	546	480	414	349.50	285.75	223.50	162.75	104.25	48		600.	97.50
50															
Total earnings for life if injured at 15 years.....	$40,000	$36,320	$32,720.00	$29,120	$25,600	$22.080	$18,610	$15,240.00	$11,920.00	$8,680.00	$5,560.00	$2,560		$32.000	$5,200.00

TABLE E.

Illustrating the Monetary Valuation of the Remaining Earning Ability in the Case of an Average Laborer Suffering from Accidental Loss of Visual Acuity; Figured for the Five Decades of Working Life for Vocations Having Lower Visual Demands.

	LOSS OF VISUAL ACUITY EQUAL IN BOTH EYES AFFECTING EARNING ABILITY.										Sudden blindness of one eye, the other remaining.	
SCIENTIFIC STANDARD OF VISUAL ACUITY.	1.00 to .50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05	V {R. E.=1.00 L. E.=0 Loss figured at 18%. See p. 78.	V {R. E.=0 L. E.=.25 Loss figured at 71.3%. See table 4, part V
Economic valuation of visual acuity. See tabls B, II. page 42.	1.00	.88	.77	.66	.55	.44	.33	.22	.11	0	1.00	0.44
Percentags of remaining earning ability, also value of earning ability per hundred in dollars; arranged from the mean of exact figures. Table 6, part V, page 120.	100	87.8	75.8	64.0	52.3	40.9	29.8	19.1	8.9	0	82.	28.7
AGE — Annual Income:												
15 to 20 years (5)	$ 200	$ 175.60	$ 151.60	$ 128	$ 104.60	$ 81.80	$ 59.60	$ 38.20	$ 17.80	0	$164.00	$57.40
20 to 25 years (5)	400	351.20	303.20	256	209.20	163.60	119 20	76 40	35.60	0	328.00	114 80
25 to 50 years (25)	800	702.40	606.40	512	418.40	327.20	238.40	152.80	71.20	0	656.00	229 60
50 to 65 years (15)	600	526.80	454.80	384	313.80	245 40	178.80	114.60	53.40	0	492.00	172.20
Total earnings for life if injured at 15 years	$32,000	$23,096.00	$24,256.00	$20,480	$16,736.00	$13,088.00	$9,536.00	$6,112.00	$2,848.00	0	$26,240	$9,184.00

In cases where the blame of an accident may be laid upon the second party or where, through previous business agreement, an employer or insurance company has arranged to pay a fixed sum or a pension in case of accidental injury, the amount of the indemnity should be in accordance to a definite schedule based upon the average wages in the vocation to which the individual may belong. It should be remembered that partial loss of vision not exceeding 25 per cent. in vocations having higher visual demands and not exceeding 50 per cent. in those with lower demands does not injure the earning ability to any degree. Indemnity, for actual disability, therefore, should be granted only those whose eyes are damaged beyond reparation to a greater extent than above named.

It is only in vocations that have visual requirements that a close estimate of these visual values may be made. In those classes of business life whose followers are not engaged in manual labor, whose business capacity relies more upon brains than upon actual handiwork, our rules cannot always apply, for even a blind man could work with monetary advantage in some trades and business; but for the laborer, for the artisan and for those professions in which the visual perceptive faculties are necessary, our rules and tables may be deemed fitting. By adjusting the age scale for the pecuniary earnings, to the percentage of the actual damage as figured by the method of Magnus, we may arrive at an exact mathematical estimation of the economic damage to the individual for the loss of vision in any given case.

It may be well to discuss the value of vision. This may be summed up in one sentence, "*Sight is priceless, and, like honor, is not a marketable commodity.*" Even the mere perception of light is of inestimable value to a person who is economically blind and its value to him cannot well be calculated. Does this fact conflict with our propositions? We do not think it can be considered, as we are not dealing with any arbitrary value that might possibly be placed upon the sense of sight, but solely with the earning capacity of the eyes, which has to do with the amount and quality of remunerative work and the duration of working life. Can we apply our rules to the case of non-workers, for instance, to infants, children and those whose business does not require eye sight, or can we figure upon the ambition or possible prospects of advancement in any other profession than that in which the person is employed? It is self-evident that we can not. For instance, one of the children in a family may some day become a millionaire, whereas one of his brothers may ever remain a common laborer. There is no means of foretelling the future. We can only figure with facts, and thus our rules and estimations are based upon the compensation of the person before the accident, and this is the only proposition that can be received. Indemnification in the case of loss of sight from accidents in children, in the majority of women, in persons who are

working but temporarily at some vocation, who expect to enter another at some later period of life, will have to be given, as heretofore, by arbitrary decisions of the courts. Such reasonings are the common rules of business; for instance, a man who has no income whatever and can offer no collateral would be refused a loan of money by any bank or business corporation, and could not obtain any money except as an act of charity or for some extraneous reason foreign to the rules of business. A person with a small income, for instance, earning $1,000 a year, would be able to borrow a certain small amount, for instance, $100, but another person earning $10,000 a year would be able to borrow a vastly greater amount upon his prospects. Thus for business reasons we can only consider actual wage earners to come under our rules. As accidental injuries involving compensation for damages happen in a very large majority of cases to persons of this class, all others may be looked upon as exceptions and such cases may be left to be treated from the philanthropic standpoint.

While by this method of reasoning we are enabled to exactly estimate the amount of money that a given case may reasonably expect to earn provided he remain in the same business and exercise ordinary skill and diligence and hence accomplish an average amount of work, it must be admitted that such figures are hypothetical. However, such immense interests as those of the modern insurance companies and many other sociologic standards are successfully based upon the same principles and we must here be allowed to use them. The result to be achieved by all our computations is not the exact amount that a man will earn, but that which he may reasonably expect to receive for his labors.

§42. *Examples.*

We will now take up some specific examples to illustrate the application of our methods for determining the amount of economic damage to the individual from ocular injuries.

Example 1. For our first example we take a case that often comes up in the courts of law. An artisan whose business has higher visual demands, who has previouly had normal vision, receives an injury to one eye while working at his trade, by which the sight of the injured eye is wholly lost, the vision in the other remaining normal. The question then arises, what economic damage has this man sustained?

We have shown that in the higher class of trades, during the first year following the accident, a one-eyed person has lost 30 per cent. of his earning ability and afterwards the loss may be reckoned as 20 per cent. As a matter of convenience we will suppose that this man is injured at the 30th year of age, and that he has been earning for the previous five years $1,000.00 a year, with the expec-

tation of earning this sum annually until he is 50 years of age, when for the next 15 years his average earnings, on account of disability, due to age and the competition of younger workmen, will fall to $750.00 a year and his working life is to cease at 65 years. His total earnings for the balance of his life would then be reckoned as follows: 20 years at $1,000.00 a year; 15 years at $750.00 a year; total, $31,250.00. For the first year after the accident instead of earning $1,000.00 he may expect a loss of 30 per cent. ($300.00) and for the following nineteen years instead of $19,000.00 he would lose 20 per cent. ($3,800.00) and the following fifteen years instead of $11,250.00 he would lose 20 per cent. ($2,250.00), making a total loss for the thirty-five years of working life of $6,350.00, which is his personal economic damage, an amount which he might reasonably demand as an indemnity for the loss of earning ability due to the accident if liability of the employer or defendant could be proven. This sum should be used as the scientific basis for settlement of contested cases; modified according to American law by a reduction being made in favor of the defendant in case of extenuating circumstances or contributory negligence and an addition made thereto for actual expenses incurred by the plaintiff during his illness and damages for the pain and anguish suffered by reason thereof. These amounts must always be empirically estimated by the courts.*

EXAMPLE 2. If this man were injured at the age of 40 the same method of calculation would give him a prospective compensation of $21,250.00 for the balance of his earning life, instead of which, for the first year he would receive $700.00, for nine years more, $7,200.00, and for the fifteen years following $9,000.00; making a total economic value of $16,900.00, a resulting economic damage of $4,350.00.

EXAMPLE 3. If this man were injured at the age of 50, instead of his prospective compensation being $750.00 per year for fifteen years, or $11,250.00, for the first year after the accident he would be earning 30 per cent. less, or $525.00, and for the following fourteen years 20 per cent. less, or $8,400.00, making total economic value of $8,925.00 and total economic damage of $2,325.00.

By the use of different rates of compensation and different years other examples could be readily given. The same method of reasoning applied to the loss of one eye in case of an artist or other professional man would yield proportional results. The only difference in the calculations would be the fact that such professions usually become more remunerative as the person grows older. In the case of the common laborer, the only differences would be the lower rate of compensation and the figuring of his economic loss

*Seven thousand dollars has been recently awarded in Texas for the loss of an eye. Court Civil Appeals Texas, 1901, De La Vergne Refrigerating Machine Co. vs. Stahl.

at 20 per cent. for the first year after the accident and 18 per cent. thereafter.

We will now go on to the calculations involved in more complex cases where the same principles are to be used as those which have been invoked for simple cases:

EXAMPLE 4. We will take the case of an architect or draughtsman, in his 46th year of life, earning $3,000.00 a year, whose visual acuity in one eye is reduced by an accident to 0.50, the other remaining normal. His profession demands good vision and he is in a measure handicapped for some of his work, especially that of fine draughting. We will proceed to work out this case from the beginning and will, therefore, recapitulate our formula:

$$E = C \sqrt{P}\, \sqrt[4]{M} \sqrt[x]{C_1 + \frac{C_2}{2} \sqrt{P}\, \sqrt[4]{M}}$$

In this case the maximum C remains unchanged because this is the higher visual acuity of the sound eye $=1$. $\sqrt{P}$ the visual field, and $\sqrt[4]{M}$ the muscular action remain unchanged: the three factors each representing the value I. In this case the unknown quantity is the ability to compete,

$$\sqrt[x]{C_1 + \frac{C_2}{2} \sqrt{P}\, \sqrt[4]{M}}.$$

$C_1 + \frac{C_2}{2}$ being the arithmetical proportion of the central visual acuity of both eyes. C_1, the uninjured eye remains $=1$; C_2 the injured eye should be reduced to 0.50 of the scientific value 0.5, of the scientific standard. Looking now on plate I. on the abscis for the scientific value 0.5, trace this line upwards until we meet the economic curve II. which is for vocations having higher visual demands, and from the point where the line cuts the curve we go to the left and find there on the ordinate the economic value of the scientific estimation for the acuity of vision. This is 0.58; inserting this value into the arithmetical proportion of the acuity for both eyes, into $\frac{C_1 + C_2}{2}$ we have $\frac{1 + 0.58}{2} = 0.79$. This we insert into the factor $\sqrt[x]{\frac{C_1 + C_2}{2} \sqrt{P}\, \sqrt[4]{M}}$; we then have

$$\sqrt[x]{0.79 \sqrt{P}\, \sqrt[4]{M}}$$

in which $\sqrt{P}$ and $\sqrt{M}$ are each $=1$; the whole value is then

$$\sqrt{0.79 \times 1 \times 1}.$$

As this is a slight injury, the ability to compete is only partly impaired, so we make the root exponent X=10. This value $\sqrt[10]{0.79 \times 1 \times 1}$ we can find in plate II., curve V., where we look on the abscissa for the value 0.79, trace the line from there upwards until we meet the curve V., going from there to the left on the ordinate we find the value 0.972. If we insert this value into the formula we would find $E=1 \times 1 \times 1 \times 0.972$, which multiplied by 100 gives the earning ability $E=97,2\%$. This man being injured at his 46th year, he would expect to have earned \$60,000 during the next twenty years. His earning ability being reduced to 97.2 per cent. he would probably earn \$58,320.00, which subtracted from the reasonable expectations of his business, would leave the sum of \$1,680.00, an amount which he might expect as the indemnity for the loss of earning ability due to the accident.

EXAMPLE 5. In the case of a printer who was originally weak-sighted; the vision of one eye $n_1=0.65$ and the other $n_2=0.55$ (scientific standard); eye 1 being uninjured ($c_1=0.65$) while the visual acuity of the other has been impaired by injury to $c_2=0.20$. He is in his 26th year and has been earning \$1,000.00 annually and would reasonably expect to earn this sum for the next 25 years, after which his earnings through disabilities of his age, slowness and consequent inability to compete would probably depreciate to \$750.00 a year, making the balance of the money that he might reasonably expect to earn in the course of his life \$36,250.00. Figuring out the earning ability according to our modified formula:*

$$c_1 = n \frac{c_1}{n_1} = 0.75 \frac{0.65}{0.65} = 0.75.$$

$$c_2 = n \frac{c_2}{n_2} = 0.75 \frac{0.55}{0.55} = 0.27,$$

the maximum $c_1=c_1=0.75$ while we get for the maximum of the real acuities $c_{max.}=c_1=0.65$. The first value should be replaced professionally by 1 according to table B, p. 42; the second by 0.83. . . . .

*These numbers are found by referring to table 5, part IV without calculation. Such complicated cases as these (Cases 5 and 6) would be rarely found in practice.

To e_1 and c_2 furnishes us the quantity $E_1'=77.079$, the earning ability is therefore:

$$E = \frac{c'_{max.} \times E'}{c_{max.}} = \frac{1 \times 77.079}{0.8333} = 92.495.$$

or a permanent disability of 7.505 per cent. The amount that before the accident he might reasonably have expected to earn during the balance of his life is $36,250.00, 7.505 per cent. of which would give $2,720.50, which should be the highest amount allowed as indemnity for the permanent loss of earning ability due to the accident subject to reduction for cause and to increase as determined in Example I.

EXAMPLE 6. In the case of a laborer who was originally blind in one eye, the other being weak-sighted ($n=0.45$), who at the age of 40 years suffered an injury to the seeing eye, and there remains only a visual acuity of $c_2=0.25$, because $c_1=0$ has to be used, there is $c_{max.}=c_2=0.25$ (professionally $=0.444\ldots$) and the modified acuity of vision $c_1=0$, the maximum of both values will be:

$$c_2' = n\frac{c_2}{n_2} = 0.50\frac{0.25}{0.45} = 0.28$$

which corresponds professionally with the figures:

$$\frac{100 + 0.28 - 5}{45} = 0.511$$

To c_1 and c_1 belong, according to plate II., or by calculating the root $E_1=39.582$; the earning ability is therefore:

$$E = \frac{c_{max.} E'}{c_{max.}} = \frac{0.511 \ldots 39.582}{0.444} = 45.519$$

the loss of the earning ability being 54.481 per cent. At the age of 40 years he would be earning $800.00 per year and might reasonably expect to earn this amount for 10 years, after which, owing to physical infirmities and increasing age, his earning powers would probably be less, being reduced to $600.00 per annum; he would, therefore, expect to earn, if he had remained in good physical health, the sum of $17,000.00; after the accident his earning powers being reduced to 45.519 per cent., he would be justly entitled to an indemnity in proportion, which would be 54.481 per cent. of $17,000.00=$9,261.77, which would be likewise subject to increase or decrease according to conditions of the accident as established by law.

EXAMPLE 7. A traveling salesman, 45 years of age, who recently consulted me had bi-nasal hemianopsia with a remaining central acuity of 0.20 in both eyes. He stated that he had this condition for a number of years and was enabled to do all his work satisfactorily until recently when the visual acuity had failed, from what he previously thought was normal, to 0.20. He was now able to get about and sell some goods, but largely from memory, as he

could not read his business catalogues and letters, and was about to give up his business entirely. His income depended upon sales made and was about $2,000.00 a year. Thus for the balance of his working life his expectations would be for 20 years at $2,000.00 a year, amounting to $40,000.00. According to his experience he was able to do all his work until the visual acuity failed and we have shown (page 60) that nasal hemianopsia does not necessarily incur earning disability. Therefore, we would figure his economic damage from the amount of the reduction of the visual acuity; the scientific standard, 0.20, would have an economic equivalent of 0.38. Reasoning from this economic loss of acuity and inserting same and working out the formula, we find that the value of his economic powers is about 30 per cent., which has a pecuniary valuation of $600.00 per annum, which agrees fairly well with his lessened expectations of earning if his vision should remain as it is, but if it further deteriorates he will be totally incapacitated.

EXAMPLE 8. In the case of an iron moulder 40 years of age receiving a blow upon his head which laid him up from work for a year and caused permanent homonymous hemianopsia. From the effects of the accident, he being laid up for a year, afterwards being obliged to take a lower position in the same line of work, which paid him about one-third less, we would figure his theoretic loss by means of table on page 61 as 31.6 per cent., which agrees near enough with the actual conditions of his work, for he was previously earning $4.00 a day and afterwards was enabled to earn but $2.75 a day; the total economic damage can be readily figured in this case as in the foregoing.

Examples of such character might be multiplied and cases cited from the most simple form to that of the most complicated character. The foregoing are surely sufficient demonstration of the fact that the percentage of economic loss and its pecuniary equivalent in any given case of ocular injury, may be readily ascertained. The diagrams and tables offer an easy method for this mathematical calculation. In but few cases will it be found necessary to figure out the formula in full, for reference to the proper table in part IV. will at once give the percentage of earning ability. The relative values of the visual acuity, the visual field and the ocular musculature must certainly be estimated by a scientific examination of the eyes, preferably by an oculist: these having been obtained the other factors, the age and business of the workman and his wages may be introduced into the formula and the probable pecuniary personal damage thereby readily calculated. Competent practitioners of law or medicine or insurance officials may by these methods determine with exactness, in a manner fair and just to all parties, the amount of damage to the earning ability of their clients which may have occurred as a result of accidental injuries to the eyes, and this should be considered the principal factor in the settlement of legal claims.

PART FOURTH.

Tables for Estimation of the Different Forms of Damage to the Visual Earning Ability.

Tables I to VI. Injuries to the Visual Acuity.

Tables VII to IX. Injuries to the Visual Field both Uncomplicated and Complicated with Damage to the Visual Acuity.

Tables X to XII. Uncomplicated and Complicated Damages of the Ocular Muscles.

Tables XIII to XXII. Various Forms of Damage in Monocularism.

Earning Ability and its Impairment. One Eye Normal, the Other Injured but not Blind.

TABLE I.

Vocations with Higher Visual Demands.

The *full* professional visual acuity corresponds with the scientific standard 0.75; the ability to compete is figured with $\sqrt[10]{}$ until the visual acuity falls to 0.15, then with $\sqrt[10]{}$ or $\sqrt[5]{}$.

Degree of Scientific Acuity.	Earning Ability.	Impairm't of Earning Ability.
1—0.75	100	0.0
0.70	99.5	0.5
0.65	99.1	0.9
0.60	98.6	1.4
0.55	98.1	1.9
0.50	97.6	2.4
0.45	97.1	2.9
0.40	96.6	3.4
0.35	96.0	4.0
0.30	95.4	4.6
0.25	94.7	5.3
0.20	94.0	6.0
0.15	93.3	6.7
If the acuity falls below 0.15 without blindness.	84.4 or 78.0	15.6 or 22.0

TABLE II.

Vocations with Lower Visual Demands.

The *full* professional visual acuity corresponds with the scientific standard 0.5; the ability to compete as figured with $\sqrt[10]{}$ until the visual acuity falls below 0.5, then with $\sqrt[10]{}$ or $\sqrt[7]{}$.

Degree of Scientific Acuity.	Earning Ability.	Impairm't of Earning Ability.
1—1.50	100	0.0
0.45	99.4	0.6
0.40	98.8	1.2
0.35	98.1	1.9
0.30	97.5	2.5
0.25	96.7	3.3
0.20	96.0	4.0
0.15	95.1	4.9
0.10	94.2	5.8
0.05	93.3	6.7
If the acuity falls below 0.05 without blindness.	84.4 or 81.6	15.6 or 18.4

* In the German editions of Magnus' work Dr. Hugo Rohr has carried out the calculations to the thousandths of a per cent. The figures are too complicated for practical use, and as our calculations are dependent largely upon probabilities which are more or less variable, the American editor has only accepted the calculations to 1-10 per cent. as printed in the following tables; where there would be a fractional remainder less than 0.1 per cent. it has been added to the amount of the impairment; on account of this simplification the figures are slightly different than those in the II German Edition.

Earning Ability and its Impairment, One Eye Blind, the Other Weaksighted.

TABLE III.

Vocations with Higher Visual Demands.

Full acuity of vision 1, corresponds with the scientific standard 0.75, and the ability to compete is figured with $\sqrt[5]{}$.

Visual Acuity of the Weaksighted Eye.	Earning Ability.	Impairment of the Earning Ability.	Reduction Permissible After One Year.
0.70	62.2	37.8	29.7
0.65	55.5	44.5	37.3
0.60	48.9	51.1	44.7
0.55	42.4	57.6	52.0
0.50	36.1	63.9	59.1
0.45	30.0	70.0	66.1
0.40	24.1	75.9	72.7
0.35	18.4	81.6	79.1
0.30	13.0	87.0	85.2
0.25	8.0	92.0	90.9
0.20	3.5	96.5	96.0
0.15	0.0	100.0	100.0

TABLE IV.

Vocations with Lower Visual Demands.

Full acuity of vision 1, corresponds with the scientific standard 0.50, and the ability to compete is figured with $\sqrt[5]{}$.

Visual Acuity of the Weaksighted Eye.	Earning Ability.	Impairment of the Earning Ability.	Reduction Permissible After One Year.
0.45	63.5	36.5	28.6
0.40	54.5	45.5	38.7
0.35	45.7	54.3	48.6
0.30	37.1	62.9	58.3
0.25	28.7	71.3	67.6
0.20	20.7	79.3	76.6
0.15	13.0	87.0	85.3
0.10	5.9	94.1	93.3
0.05	0.0	100.0	100.0

TABLE V. Earning Ability, Both Eyes Suffering Injury to the Visual Acuity of Equal or Different Degrees.

Vocations with *Higher* Visual Demands.

In the last two columns to the right and the last two columns below, the ability to compete is figured with $\sqrt[5]{}$; in the third last column to the right and also below with $\sqrt[10]{}$ or $\sqrt[5]{}$.

SCIENTIFIC STANDARD FOR VISUAL ACUITY.	1—0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	When the vision sinks below 0.15, without total blindness.	For the first year after total blindness of one eye.	For 2d year after total blindness of one eye and following.
1—0.75	100	99.5	99.1	98.6	98.1	97.6	97.1	96.6	96.0	95.4	94.7	94.0	93.3	84.4 OR 78.0	69.0	78.0
0.70	99.5	90.8	90.4	90.0	89.5	89.0	88.5	88.0	87.4	86.8	86.2	85.5	84.7	76.6 OR 70.2	62.2	70.2
0.65	99.1	90.4	81.8	81.4	80.9	80.5	80.0	79.5	78.9	78.3	77.7	77.0	76.3	69.0 OR 62.6	55.5	62.6
0.60	98.6	90.0	81.4	72.8	72.4	72.0	71.5	71.0	70.5	69.9	69.3	68.7	67.9	61.5 OR 55.2	48.9	55.2
0.55	98.1	89.5	80.9	72.4	64.0	63.6	63.1	62.7	62.2	61.6	61.0	60.4	59.7	54.0 OR 47.9	42.4	47.9
0.50	97.6	89.0	80.5	72.0	63.6	55.2	54.8	54.4	53.9	53.4	52.8	52.2	51.5	46.6 OR 40.8	36.1	40.8
0.45	97.1	88.5	80.0	11.5	63.1	54.8	46.6	46.2	45.8	45.3	44.7	44.2	43.5	39.3 OR 33.8	30.0	33.8
0.40	96.6	88.0	79.5	71.0	62.7	54.4	46.2	38.1	37.7	37.3	36.8	36.2	35.6	32.2 OR 27.2	24.1	27.2
0.35	96.0	87.4	78.9	70.5	62.2	53.9	45.8	37.7	29.8	29.4	29.0	28.4	27.8	25.2 OR 20.8	18.4	20.8
0.30	95.4	86.8	78.3	69.9	61.6	53.4	45.3	37.3	29.4	21.7	21.3	20.8	20.3	18.3 OR 14.7	13.0	14.7
0.25	94.7	86.2	77.7	69.3	61.0	52.8	44.7	36.8	29.0	21.3	13.9	13.5	13.0	11.7 OR 9.0	8.0	9.0
0.20	94.0	85.5	77.0	68.7	60.4	52.2	44.2	36.2	28.4	20.8	13.5	6.4	6.0	5.4 OR 3.9	3.5	3.9
0.15	93.3	84.7	76.3	67.9	59.7	51.5	43.5	35.6	27.8	20.3	13.0	6.0	0.0	0.000	0.0	0.0
When the vision sinks below 0.15, but without total blindness.	84.4 OR 78.0	76.6 OR 70.2	69.0 OR 62.6	61.5 OR 55.2	54.0 OR 47.9	46.6 OR 40.8	39.3 OR 33.8	32.2 OR 27.2	25.2 OR 20.8	18.3 OR 14.7	11.7 OR 9.0	5.4 OR 3.9	0.0	0.000	0.0	0.0
For the first year after total blindness of one eye.	68.0	62.2	55.5	48.9	42.4	36.1	30.0	24.1	18.4	13.0	8.0	3.5	0.0	0.000	0.0	0.0
For 2d year after total blindness of one eye and following.	78.0	70.2	62.6	55.2	47.9	40.8	33.8	27.2	20.8	14.7	9.0	3.9	0.0	0.000	0.0	0.0

TABLE VI.

Earning Ability, Both Eyes Suffering Injury to the Visual Acuity of Equal or Different Degrees.

Vocations with *Lower* Visual Demands.

In the last two columns to the right and the last two columns below, the ability to compete is figured with $\sqrt[5]{}$; in the third last column to the right and also below with $\sqrt[10]{}$ or $\sqrt[7]{}$.

SCIENTIFIC STANDARD FOR VISUAL ACUITY.	1—0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05	When the vision sinks below 0.05, without total blindness.	For the first year after total blindness of one eye.	For 2d year after total blindness of one eye and following.
0.50	100	99.4	98.8	98.1	97.5	96.7	96.0	95.1	94.2	93.3	84.4 OR 81.6	72.6	81.6
0.45	99.4	87.8	87.2	86.6	86.0	85.3	84.6	83.8	82.9	81.9	74.1 OR 71.3	63.5	71.3
0.40	98.8	87.2	75.8	75.2	74.6	74.0	73.3	72.5	71.7	70.7	64.0 OR 61.2	54.5	61.2
0.35	98.1	86.6	75.2	64.0	63.4	62.8	62.2	61.4	60.6	59.7	54.0 OR 51.3	45.7	51.3
0.30	97.5	86.0	74.6	63.4	52.3	51.8	51.2	50.5	49.7	48.8	44.2 OR 41.6	37.1	41.6
0.25	96.7	85.3	74.0	62.8	51.8	40.9	40.4	39.8	39.1	38.2	34.5 OR 32.3	28.7	32.3
0.20	96.0	84.6	73.3	62.2	51.2	40.4	29.8	29.3	28.6	27.8	25.2 OR 23.2	20.7	23.2
0.15	95.1	83.8	72.5	61.4	50.5	39.8	29.3	19.1	18.5	17.8	16.1 OR 14.6	13.0	14.6
0.10	94.2	82.9	71.7	60.6	49.7	39.1	28.6	18.5	8.9	8.3	7.5 OR 6.6	5.9	6.6
0.05	93.3	81.9	70.7	59.7	48.8	38.2	27.8	17.8	8.3	0.0	0.000	0.0	0.0
When the vision sinks below 0.05, but without total blindness.	84.4 OR 81.6	74.1 OR 71.3	64.0 OR 61.2	54.0 OR 51.3	44.2 OR 41.6	33.5 OR 32.3	25.2 OR 23.2	16.1 OR 14.6	7.5 OR 6.6	0.0	0.000	0.0	0.0
For the first year after total blindness of one eye.	72.6	63.5	54.5	45.7	37.1	28.7	20.7	13.0	5.9	0.0	0.000	0.0	0.0
For 2d year after total blindness of one eye and following.	81.6	71.3	61.2	51.3	41.6	32.3	23.2	14.6	6.6	0.0	0.000	0.0	0.0

TABLE VII.

Earning Ability and its Impairment in Disorders of the Visual Field with Normal Central Visual Acuity.

	VARIETY OF DEFECT.	Arithmetical Value of the Remaining Field.	Earning Ability.	Impairment of the Earning Ability.
1.	Partial defects in one field Concentric contraction of the field of one eye Loss of one temporal half of one eye Loss of the full field of one eye	5/6	90.4	9.6
2.	Small concentric contraction of both fields reaching to 60° Loss of the temporal half of both fields	2/3	80.0	20.0
3.	Homonymous hemianopsia dextra vel sinistra, superior vel inferior	1/2	68.3	31.7
4.	Great concentric contraction of both fields reaching 30°	1/3	54.6	45.4
5.	Total concentric contraction of both fields reaching to 5 per cent.	0	0.0	100.0
6.	Loss of the nasal halves of both fields Loss of the nasal half of one field	1	100.0	0.0

TABLE VIIa.

Ability to Compete and Impairment of Visual Fields for Vocations with Higher and Lower Visual Demands, Figured Separately.

Case.	Remaining Fraction of P.	K figured with $\sqrt[5]{}$ for *Higher* demands (for more *serious* injuries)		K figured with $\sqrt[7]{}$ for *Lower* demands (for more *serious* injuries)	
		Earning Ability.	Impairment of the Earning Ability.	Earning Ability.	Impairment of the Earning Ability.
1	5/6	89.6	10.4	90.1	9.9
2	2/3	78.4	21.6	79.3	20.7
3	1/2	65.9	34.1	67.2	32.8
4	1/3	51.7	48.3	53.3	46.7
5	0	0	100	0	100
6	1	100	0	100	0

TABLE VIII.

Earning Ability in Visual Field Defects of Both Eyes with Equally Diminished Visuual Acuity.

For Vocations with Higher Visual Demands.

	VARIETY OF DEFECT.	Arithmetical Value of the Remaining Field.	1—0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15
1.	Partial defects in one field Concentric contraction of the field of one eye. (Lower and higher degrees) Loss of the temporal half of one field	5/6	90.4	82.2	74.0	65.9	57.9	49.9	42.2	34.5	27.0	19.6	12.6	5.8	0.0
2.	Small concentric contraction of both fields reaching 60° Loss of the temporal halves of both fields	2/3	80.0	72.7	65.4	58.3	51.2	44.2	37.3	30.5	23.8	17.4	11.1	5.2	0.0
3.	Homonymous Hemianopsia dextra vel sinistra, superior vel inferior	1/2	68.3	62.0	55.8	49.7	43.7	37.7	31.8	26.0	20.3	14.8	9.5	4.4	0.0
4.	Great concentric contraction of both fields reaching 30°	1/3	54.6	49.6	44.7	39.8	34.9	30.2	25.4	20.8	16.3	11.8	7.6	3.5	0.0
5.	Total concentric contraction of both fields reaching 5°	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.	Loss of the nasal halves of both fields Loss of the nasal half of one field	1	100.0	As the field defects in these cases do not condition an impairment of the earning ability, only the defect of the visual acuity should be indemnified. (Table V).											

TABLE IX.

Earning Ability in Visual Field. Defects of Both Eyes with Equally Diminished Visual Acuity.

For Vocations with Lower Visual Demands.

	VARIETY OF DEFECT.	Arithmetical Value of the Remaining Field.	1—0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
1.	Partial defects in one field Concentric contraction of the field of one eye. (Lower and higher grades) Loss of the temporal half of one field	5/6	90.4	79.4	68.6	57.9	47.3	37.0	27.0	17.2	8.0	0.0
2.	Small concentric contraction of both fields reaching 60° Loss of the temporal halves of both fields	2/3	80.0	70.2	60.6	51.2	41.9	32.7	23.8	15.2	7.1	0.0
3.	Homonymous hemianopsia dextra vel sinistra, superior vel inferior	1/2	68.3	60.0	51.8	43.7	35.7	27.9	20.3	13.0	6.0	0.0
4.	Greater concentric contraction of both fields reaching 30°	1/3	54.6	48.0	41.4	34.9	28.6	22.3	16.3	10.4	4.8	0.0
5.	Total concentric contraction of both fields reaching 5°	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.	Loss of the nasal halves of both fields Loss of the nasal half of one field	1	100.0	As the field defects in these cases do not condition an impairment of the earning ability, only the defect of the visual acuity should be indemnified. (Table VI).								

TABLE X.

Earning Ability and Impairment from Non-Complicated Disorders of the External Ocular Muscles.

KIND OF INJURY.	Arithmetical value of the remaining muscles.	Acuity of vision of the eye used for working.	Earning ability.	Loss of earning ability.
Paralysis of the muscles of only one eye	1	1—0.75 Resp. 1—0.50	75.4	24.6
Paralysis of the muscles of both eyes; in the working eye only one muscle is paralyzed	5/6	1—0.75 Resp. 1—0.50	71.8	28.2
Paralysis of the muscles of both eyes; in the working eye two muscles are paralyzed	4/6	1—0.75 Resp. 1—0.50	67.5	32.5
Paralysis of the muscles of both eyes; in the working eye three muscles are paralyzed	3/6	1—0.75 Resp. 1—0.50	62.3	37.7
Paralysis of the muscles of both eyes; in the working eye four muscles are paralyzed	2/6	1—0.75 Resp. 1—0.50	55.8	44.2
Paralysis of the muscles of both eyes; in the working eye five muscles are paralyzed	1/6	1—0.75 Resp. 1—0.75	46.1	53.9
Paralysis of all the muscles used by both or by the working eye	0	1—0.75 Resp. 1—0.50	0.0	100.0

TABLE XI.

Earning Ability in Paralysis of the Ocular Muscles Complicated with Disturbances of the Visual Acuity.

For Vocations with **Higher** Visual Demands.

Number of the museles left functionable in the eye used for working.	Visual Acuity 1—0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15
All muscles work of one eye	75.4	68.6	61.7	55.0	48.3	41.7	35.2	28.8	22.5	16.4	10.5	4.9	0.0
Five muscles work of one eye	71.8	65.2	58.7	52.3	45.9	39.6	33.4	27.4	21.4	15.6	10.0	4.6	0.0
Four muscles work of one eye	67.5	61.3	55.2	49.2	43.2	37.3	31.5	25.7	20.1	14.6	9.4	4.3	0.0
Three muscles work of one eye	62.3	56.7	51.0	45.4	39.9	34.4	29.1	23.8	18.6	13.5	8.6	4.0	0.0
Two muscles work of one eye	55.8	50.7	45.6	40.6	35.7	30.8	26.0	21.3	16.6	12.1	7.7	3.6	0.0
One muscle works of one eye	46.1	41.9	37.7	33.6	29.5	25.4	21.5	17.6	13.7	10.0	6.4	2.9	0.0

TABLE XII.

Earning Ability in Paralysis of the Ocular Muscles Complicated with Disturbances of the Visual Acuity.

For Vocations with **Lower** Visual Demands.

Number of the museles left functionable in the eye used for working.	Visual Acuity 1—0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
All museles work of one eye	75.4	66.3	57.2	48.3	39.5	30.9	22.5	14.4	6.7	0.0
Five museles work of one eye	71.8	63.0	54.4	45.9	37.6	29.4	21.4	13.7	6.4	0.0
Four muscles work of one eye	67.5	59.3	51.2	43.2	35.3	27.6	20.1	12.9	6.0	0.0
Three museles work of one eye	62.3	54.8	47.3	39.9	32.6	25.5	18.6	11.9	5.5	0.0
Two muscles work of one eye	55.8	49.0	42.3	35.7	29.2	22.8	16.6	10.6	4.9	0.0
One muscle works of one eye	46.1	40.5	34.9	29.5	24.1	18.9	13.7	8.8	4.1	0.0

TABLE XIII.

Earning Ability and Impairment in Disturbances of the Visual Acuity in an Originally One-Eyed Person.
(The One-Eyed Condition in a **Professional** Sense—i. e., the Other Eye is too Weaksighted for Work, Although the Eye Is Present.)

The ability to compete is figured with $\sqrt[10]{V}$.

Vocations with **Higher** Visual Demands.

Visual Acuity.	1—0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15
Earning ability	100	90.8	81.8	72.8	64.0	55.2	46.6	38.1	29.8	21.7	13.9	6.4	0.0
Impairment	0.00	9.2	18.2	27.2	36.0	44.8	53.4	61.9	70.2	78.3	86.1	93.6	100

TABLE XIV.

Earning Ability and Impairment in Disturbances of the Visual Acuity in an Originally One-Eyed Person.
(The One-Eyed Condition in a **Professional** Sense.)

Vocations with **Lower** Visual Demands.

Visual Acuity.	1—0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0 05
Earning ability	100	87.8	75.8	64.0	52.3	40.9	29.8	19.1	8.9	0.0
Impairment	0.00	12.2	24.2	36.0	47.7	59.1	70.2	80.9	91.1	100

TABLE XIIIa.

Earning Ability and Impairment if the Injury of One Muscle has to be Valued Correspondingly Higher, in Special Vocations.

Number of muscles remaining.	Arithmetical value of M.	K figured with $\sqrt[5]{}$ (higher demands, only for more serious injuries.)		K figured with $\sqrt[7]{}$ (lower demands, only for more serious injuries.)	
		Earning ability.	Impairment.	Earning ability.	Impairment.
6	1	69.1	30.9	72.6	27.4
5	5/6	65.5	34.5	68.9	31 1
4	4/6	61.2	38.8	64.7	35.3
3	3/6	56.2	43.8	59.6	40.4
2	2/6	49.7	50.8	53.1	46.9
1	1/6	40.4	59.6	43.5	56.5
0	0	0	100	0	100

TABLE XV.

Earning Ability and Impairment in Disturbaeces of the Visual Acuity in an Originally One-Eyed Person.

The one-eyed condition in a *seientific* sense, *i. e.* the other eye is totally blind. (The ability to compete is figured with $\frac{5}{V}$.)

Vocations with *Higher* Visual Demands.

Visual Acuity.	1—0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15
Earning ability..	100	90.0	80.3	70 8	61.4	52.3	43.5	34.9	26.7	18 9	11.6	5.0	0 0
Impairment.....	0.0	10.0	19.7	29.2	38.6	47.7	56.5	65.1	73.3	81.1	88.4	95.0	100

TABLE XVI.

Earning Ability and Impairment in Disturbances of the Visual Acuity in an Originally One-Eyed Person.

The one-eyed condition in a *scientific* sense. (The ability to compete is figured with $\frac{7}{V}$.)

Vocations with *Lower* Visual Demands.

Visual Acuity.	1—0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
Earning ability.....	100	87.4	75.0	62.9	51.0	39.5	28.4	17.9	8.1	0.0
Impairment	0.0	12.6	25.0	37.1	49.0	60.5	71.6	82.1	91.9	100

TABLE XVII.

Earning Ability and Impairment in Disturbances of the Visual Field of an Originally One-Eyed Person.

Variety of Defect of Visual Field.	Arithmetical value of the remaining field.	One-eyed condition in a professional sense.				One-eyed condition in a scientific sense.			
		Professional visual demands.				Professional visual demands.			
		Higher.		Lower.		Higher.		Lower.	
		Visual Acuity.				Visual Acuity.			
		1—0.75 E'rning Ability.	1—0.75 Impairment.	1—0.50 E'rning Ability.	1—0.50 Impairment.	1—0.75 E'rning Ability.	1—0.75 Impairment.	1—0.50 E'rning Ability	1—0.50 Impairment.
Loss of the nasal half,	3/5	75.5	24.5	75.5	24.5	73.6	26.4	74.6	25.4
Small concentric contract'n	8/15	67.7	29.3	70.7	29.3	68.5	31.5	69.8	30.2
Loss of the temporal half, Great concentric contraction, reaching 30°.	2/5	60.4	39.6	60.4	39.6	57.7	42.3	59.2	40.8

TABLE XVIII.

Earning Ability and Impairment in Disturbances of the External Ocular Muscles of an Originally One-Eyed Person.

Variety of Muscular Defect.	Arithmetical value of the remaining field.	One-eyed condition in a professional sense.				One-eyed condition in a scientific sense.			
		Professional visual demands.				Professional visual demands.			
		Higher.		Lower.		Higher.		Lower.	
		Visual Acuity.				Visual Acuity.			
		1—0.75 E'rning Ability.	1—0.75 Impairment.	1—0.50 E'rning Ability.	1—0.50 Impairment.	1—0.75 E'rning Ability.	1—0.75 Impairment.	1—0.50 E'rning Ability.	1—0.50 Impairment.
Loss of 1 muscle,	5/6	95.1	4.9	95.1	4.9	94.6	5.4	94.9	5.1
Loss of 2 muscles,	4/6	89.4	10.6	89.4	10.6	88.5	11.5	89.0	11.0
Loss of 3 muscles,	3/6	82.6	17.4	82.6	17.4	81.2	18.8	82.0	18.0
Loss of 4 muscles,	2/6	73.9	26.1	73.9	26.1	71.9	28.1	73.0	27.0
Loss of 5 muscles.	1/6	61.0	39.0	61.0	39.0	58.4	41.6	59.9	40.1

TABLE XIX.

Earning Ability of an Originally One-Eyed Person with Disturbances of the Visual Acuity Complicated with Defects of the Visual Field. The One-Eyed Condition in a *Professional* Sense.

(The ability to compete is figured with $\frac{10}{V}$.)

Vocations with Higher Visual Demands.

Kind of visual field defect.	Arithmetical value of the field.	1—0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15
Loss of the nasal half	3/5	75.5	68.6	61.7	55.0	48.3	41.7	35.2	28.8	22.5	16.4	10.5	4.9	0
Concentric contract'n to 60° (outer) and 40° (inner),	8/15	70.7	64.3	57.9	51.5	45.3	39.1	33.0	20.0	21.1	15.4	9.8	4.5	0
Loss of the temporal half Concentric contraction reaching to 30°.	2/5	60.4	54.9	49.4	44.0	38.6	33 3	28.1	23.0	18.0	13.1	8.4	3.9	0

TABLE XX.

Earning Ability of an Originally One-Eyed Person with Disturbances of the Visual Acuity and Visual Field. The One-Eyed Condition in a *Professional* Sense.

(The ability to compete is figured with $\frac{10}{V}$.)

Vocations with Lower Visual Demands.

Kind of visual field defect.	Arithmetical value of the field.	1—0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
Loss of the nasal half,	3/5	70.5	66.3	57.2	48.3	39.5	30.9	22.5	14.4	6.7	0
Concentric contraction to 60° (outer) and 39° (inner),	8/15	70.7	62.1	53.6	45.3	37.0	29.0	21.1	13.5	6.3	0
Loss of the temporal half, Concentric contraction reach'g to 30°	2/5	60.4	53.0	45.8	38.6	31.6	24.7	18.0	11.5	5.3	0

TABLE XXI.

Earning Ability of an Originally one-eyed Person with Disturbances of the Visual Acuity and Visual Field.

The one-eyed condition in a *scientific* sense. (The ability to compete is figured with $\frac{5}{5}$).

Vocations with *Higher* Visual Demands.

Kind of visual field defect.	Arithmetical value of the field.	1—0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15
Loss of the nasal half	3/5	73.6	66.3	59.1	52.1	45.2	38.5	32.0	25.7	19.6	13.9	8.5	3.7	0
Concentric contract'n to 60° (outer) and 40° (inner),	8/15	68.5	61.7	55.1	48.5	42.1	35.9	29.8	23.9	18.3	12.9	7.9	3.5	0
Loss of the temporal half Concentric contraction renching to 30°,	2/5	57.7	51.9	46.3	40.8	35.4	30.2	25.1	20.1	15.4	10.9	6.7	2.9	0

TABLE XXII.

Earning Ability of an Originally one-eyed Person with Disturbances of the Visual Acuity and Visual Fields.

The one-eyed condition in a *scientific* sense. (The ability to compete is figured with $\frac{7}{7}$.)

Vocations with *Lower* Visual Demands.

Kind of visual field defect.	Arithmetical value of the field.	1—0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
Loss of the nasal half,	3/5	74.6	65.2	56.0	46.9	38.1	29.5	21.2	13.3	6.0	0
Concentric contraction to 60° (outer) and 40° (inner)	8/15	69.8	61.0	52.3	43.9	35.6	27.6	19.8	12.5	5.6	0
Loss of the temporal half, Concentric contraction reach'g to 30°	2/3	59.2	51.7	44.4	37.2	30.2	23.5	16.8	10.6	4.8	0

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ALPHABETICAL INDEX.

ALPHABETICAL INDEX.

PLATES II AND III.

Near and Distance Test Types.

PLATE II.

JAEGER'S TYPES WITH DISTANCES AT WHICH THEY MAY BE NORMALLY SEEN AS RENDERED BY THE SCIENTIFIC AND ECONOMIC STANDARDS.

FOR NEAR TEST OF THE VISUAL ACUITY.

Economic Standard for Lower Visual Demands.	Scientific Standard.	Economic Standard for Higher Visual Demands.
0.3	0.6	0.45

Of the seventy-one conventions held here during the present year, thirty-two were of national associations, and thirty-nine state. Since the annual meeting of a year ago thirty-nine national conventions have been secured for Milwaukee through the agency of the Citizens' Business League, three of which were for the present year and have already been held here, namely: American Society of Mechanical Engineers, United States

0.4	0.8	0.6

Weather Bureau Officials, and the American Bankers' Association. For next year the list includes twenty-eight national and thirty-four state conventions, and for the year following, we have already booked eight national and ten state conventions. In addition to those already

0.5	1.0	0.75

secured, we are working with a number of important associations which we still hope to secure for Milwaukee next year. Every time we go after a convention, if we do not win out, we

0.75	1.5	1.2

enter a strong wedge to bring it here another year. Among those we are hoping to secure, selections having been referred to executive committees, are the Traveling

~~1.05~~ 1.50	3.0	2.4

Freight Agents' Association of the United States, the National Lumber Com

PLATE III.

SNELLEN'S TYPES WITH DISTANCES AT WHICH THEY MAY NORMALLY BE SEEN AS RENDERED BY THE SCIENTIFIC AND ECONOMIC STANDARDS.

FOR DISTANT TEST OF THE VISUAL ACUITY.

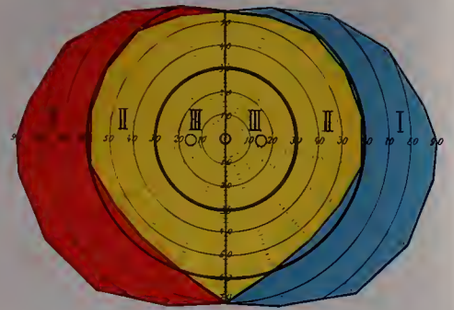
Economic Standard for Lower Visual Demands, 12 meters.	Scientific Standard, 24 meters.	Economic Standard for Higher Visual Demands, 18 meters.
		
9 meters.	18 meters.	12 meters
		
3 meters.	6 meters.	4½ meters.
		

PLATE IV.

The Visual Field.

PLATE IV.

Figure 1.

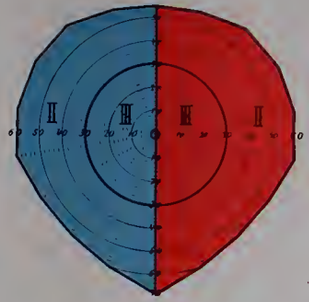


Normal Binocular Visual Field.

The yellow area is the portion common to both eyes; the red belongs to the left and the blue to the monocular field of the right eye.

The heavy black circles divide the fields into three zones of equal economic importance. Chapter VI, § 13.

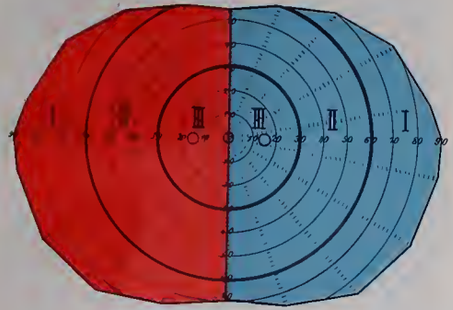
Figure 2.



Loss of the Temporal Halves of Both Visual Fields

Valuation of the Remainder is ⅔ of the Normal.
Chapter IX, § 19.

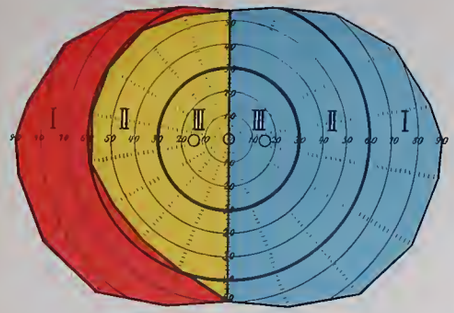
Figure 3.



Loss of the Nasal Halves of Both Visual Fields.

Valuation of the Remainder is 1.
Chapter IX, § 19.

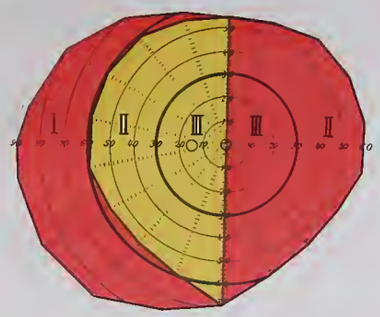
Figure 4.



Loss of the Nasal Half of the Visual Field of the Left Eye.

Valuation of the Remainder is 1.
Chapter IX, § 19.

Figure 5.



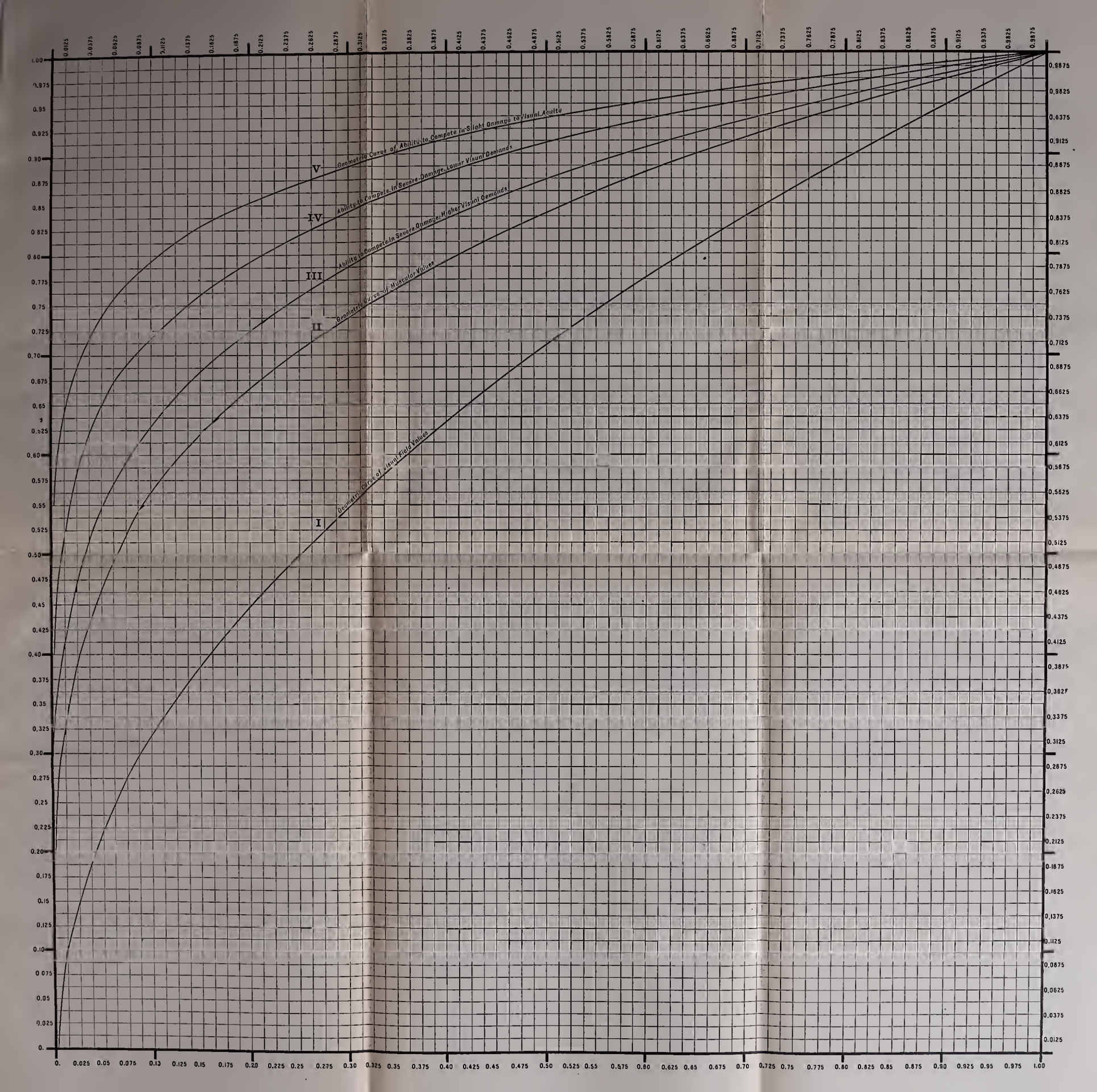
Loss of the Temporal Half of the Visual Field of the Right Eye.

Valuation of the Remainder is ⅚.
Chapter IX, § 19.

Normal and Damaged Visual Fields with Economic Valuation.

PLATE V.

Curves for Valuation of the Visual Field, of the Muscular Action and of the Ability to Compete.


V
Geometric Curve of Ability to Compete in Slight Damage to Visual Acuity
IV
Ability to Compete in Severe Damage, Lower Visual Demands
III
Ability to Compete in Severe Damage, Higher Visual Demands
II
Geometric Curve of Muscular Values
I
Geometric Curve of Visual Field Values